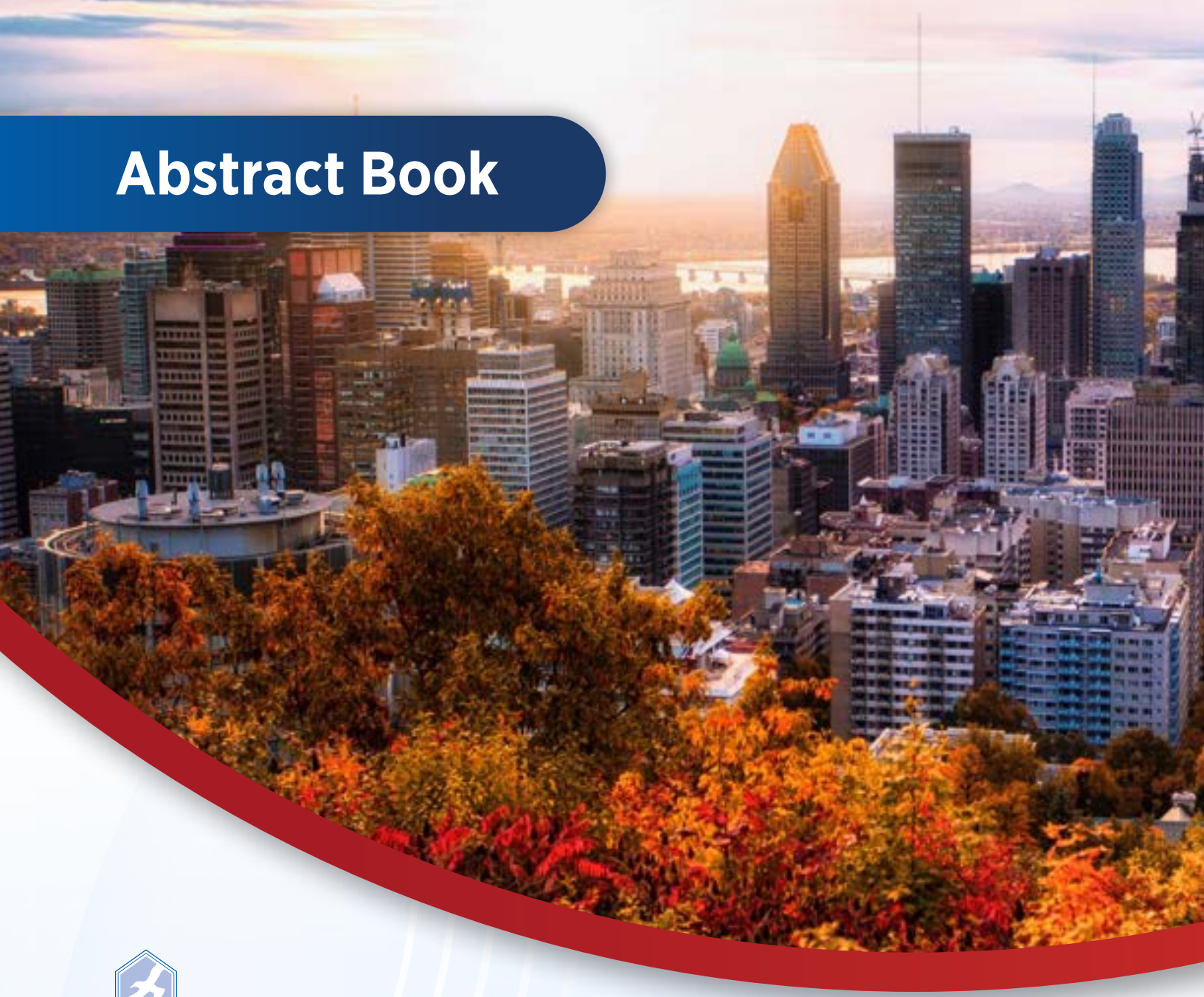
Abstract Book



SETAC North America 47th Annual Meeting

2–5 November 2026 • Montreal, Quebec, Canada

One Planet Shared Future

Abstract Book

SETAC North America 47th Annual Meeting

Table of Contents

About SETAC 3
Daily Schedule 5
Program Committee 6
Meeting Supporters 7
Environmental (Human and Ecological) Toxicology and Stress Response 9
Aquatic Toxicology, Ecology and Stress Response 121
Wildlife Toxicology, Ecology and Stress Response 271
Chemistry and Exposure Assessment 338
Policy, Management and Communication 619
Systems Approaches 651
Environmental (Human and Ecological) Risk Assessment 691
Engineering, Remediation and Restoration 791
Author Index 808
Affiliation Index 942

This book comprises the abstracts from the 47th annual meeting of the Society of Environmental Toxicology and Chemistry – North America (SETAC North America), conducted from 2–5 November 2026 in Montreal, Quebec, Canada.

The abstracts are reproduced as accepted by SETAC staff and the program committee. They appear in order of abstract code and alphabetical order per presentation type. The poster spotlight abstracts are included in the list of poster abstracts. The presenting author of each abstract is highlighted in bold.

No part of this publication may be reproduced, distributed, stored, or transmitted in any form or by any means, including photocopying, recording or other electronic or mechanical methods, without permission in writing from the copyright holder.

All rights reserved. Authorization to photocopy items for internal or personal use, or for the purpose or internal use of specific clients, may be granted by the Society of Environmental Toxicology and Chemistry (SETAC), provided that the appropriate fee is paid directly to the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923 USA (+1 978 750 8400) or to SETAC. Before photocopying items for educational classroom use, please contact the Copyright Clearance Center (www.copyright.com) or the SETAC Office in North America (+1 202 677 3001, setac@setac.org).

SETAC's consent does not extend to copying for general distribution, promotion, creating new works or resale. Specific permission must be obtained in writing from SETAC for such copying. Direct inquiries to SETAC, 712 H Street NE, Suite 1889, Washington, DC, USA.

© 2026 Society of Environmental Toxicology and Chemistry (SETAC)

International Standard Serial Number 1087-8939

About SETAC

The Society of Environmental Toxicology and Chemistry (SETAC) is a global nonprofit professional society whose main objective is to advance environmental science and management through education, collaboration, communication and leadership.

The specific purposes of the society are:

- Provide life-long learning and professional development opportunities for all career stages,
- Foster collaboration by increasing membership, engagement, diversity and partnerships,
- Provide world-class science communication forums for members and stakeholders,
- Develop leadership of SETAC and its members in the environmental science and environmental management community,
- Participate in any and all other activities permitted under the Act and which are not inconsistent with the Corporation's main objective and qualifications as an organization described in Section 501(c)(6) of the Code.

These goals are pursued through the conduct of numerous programs including events, publications, awards and education programs.

SETAC members come from government, academia, business and nongovernmental organizations with backgrounds in chemistry, toxicology, biology, ecology, atmospheric sciences, health sciences, earth sciences, environmental engineering, hazard and risk assessment, and life cycle assessment. If you are an environmental professional with training in these or related disciplines and are engaged in the study, use or management of environmental resources, SETAC can be your professional home.

SETAC publishes peer reviewed scientific research in its journals Environmental Toxicology and Chemistry (ET&C) and Integrated Environmental Assessment and Management (IEAM).

About the Abstract Book

The titles, authors and abstracts of the presentations given at the meeting are summarized in this book. Acknowledgments and disclosures are not included for space considerations, though we recommend that authors include them in the presentations themselves. Abstracts are not peer-reviewed and therefore should not be cited.

For further information, contact one of our offices:

SETAC Africa
SETAC Europe
Avenue des Arts, 53
B-1000 Brussels, Belgium
T +32 2 772 72 81
E setac@setac.org

SETAC Latin America
SETAC North America
712 H Street NE, Suite 1889,
Washington, DC, USA
T +1 202 677 3001
E setac@setac.org

SETAC Asia-Pacific
2/290 Boundary Street, Spring Hill,
Brisbane, QLD 4000 Australia
ABN: 37 689 850 262
E setac@setac.org

www.setac.org

Environmental Quality Through Science®

Daily Schedule

MONDAY, 2 NOVEMBER

TIME (EDT)	GENERAL PROGRAM	ROOM
8:30–16:30	Professional Training Courses	View Below
8:30–17:00	SETAC North America Board of Directors Meeting	518ab
12:00–13:30	MSDT-One Health Welcome Meeting	518c
17:30–18:00	New Member Welcome	517b
18:00–18:30	Opening Ceremony	517d
18:30–20:30	Opening Reception and Exhibits	220b–e

TUESDAY, 3 NOVEMBER

TIME	GENERAL PROGRAM	ROOM
7:30–8:30	International Board of Environmental Risk Assessors (IBERA) Breakfast	520a
8:30–9:15	Tuesday Plenary: Steven Guilbeault	517d
9:00–10:00	Advancement and Application of Alternatives Assessment (A4) Interest Group Meeting	520b
9:15–10:15	Peer-to-Peer Resume Writing and Review Mini Workshop	518ab
12:00–13:30	Women in SETAC: Women Shaping Science and Solutions	510bd
12:00–13:30	Bayer Sponsored Lunch Session: Debating the Benefits and Risks of Artificial Intelligence in Environmental Safety Assessments	516ab
12:30–13:30	NASAC Meeting	518ab
16:30–17:30	Carolinas Regional Chapter Meeting	518ab
16:30–17:30	Animal Alternatives Interest Group Meeting	515abc
16:30–17:30	Biologics in Agriculture Interest Group Meeting	516c
16:30–18:30	Pharmaceuticals Interest Group Meeting	514abc
17:30–18:30	Pacific Northwest Regional Chapter Meeting	518ab
17:30–18:30	Wildlife Toxicology Interest Group Meeting	515abc
17:30–18:30	Bioaccumulation Science Interest Group Meeting	516c
17:30–18:30	SETAC General Assembly	516ab
17:30–19:00	Student Mentor Mix and Mingle	524abc

WEDNESDAY, 4 NOVEMBER

TIME	GENERAL PROGRAM	ROOM
7:30–8:30	Fun Run (meet at Registration Desk)	Offsite
8:00–9:00	ASTM E50.47 – Biological Effects and Environmental Fate	518ab
8:30–9:15	Wednesday Plenary: Jennifer Grenz	517d
11:45–13:45	CIAPE ICEDA Annual General Meeting	518ab
12:00–13:30	Student Lunchtime Seminar	510bd
12:00–13:30	Lunch and Learn With Pew's Safer Chemicals Project	518c
15:30–16:30	Endocrine Disruptors Interest Group Meeting	513def
15:30–16:30	Plastics Interest Group Meeting	514abc
16:30–17:30	Ecological Risk Assessment Interest Group Meeting	513def
16:30–17:30	Plants Interest Group Meeting	514abc
16:30–17:30	North Atlantic Regional Chapter Meeting	515abc
16:30–18:00	Effect Modeling Interest Group Meeting	520a
16:30–18:30	Regional Chapters Meeting	518ab
17:30–18:30	Aquatic Toxicity Testing Interest Group Meeting	510ac
17:30–18:30	Chemistry Interest Group Meeting	514abc
17:30–19:30	Metals Interest Group Reception	510ac
17:30–19:30	Early Career Social	519ab
19:30–22:00	SETAC Night on the Town at Pointe-à-Callière	Offsite
20:00–23:00	Student Trivia and Mixer	Offsite

THURSDAY, 5 NOVEMBER

TIME	GENERAL PROGRAM	ROOM
8:30–9:15	Thursday Plenary: David Rolnick	517d
12:00–13:30	SETAC Community Clean-Up	Offsite
12:00–13:30	Trifluoroacetic Acid (TFA) Mini Workshop	520a
17:30–18:00	Closing Celebration	220b–e

PROFESSIONAL TRAINING COURSES

TIME (EDT)	COURSE TITLE	ROOM
8:30–16:30	PT01 - Aquatic Organisms for Toxicity Tests - Study Design, Test Methods, Challenges, Data Interpretation and Special Topics	520a
8:30–16:30	PT03 - Dose-response Analysis Using R	520b
8:30–16:30	PT04 - Environmental Risk Assessment Methods for New Chemical Submissions: Tools and Approaches Under TSCA	520c
8:30–12:00	PT06 - Ensure Measured Chemicals Data Are Reliable and Relevant for Your Intended Purpose: Use CREED	520d
8:30–12:00	PT07 - Multi-Omic Approaches and High-Throughput Transcriptomics for AOP-Based Chemical Risk Assessment	520e
8:30–12:00	PT08 - Histopathologic Evaluation and Data Interpretation in Fish and Amphibian Endocrine Studies	520f
13:00–16:30	PT09 - Understanding Quality and Confidence in Non-Targeted Analysis: Study Design and Data Interpretation Tools	520f
13:00–16:30	PT10 - Designing Ecologically Relevant Multiple Stressor Experiments	520d
13:00–16:30	PT11 - In silico Based New Approach Methods for Chemical Assessment: Molecular and Environmental Fate Modeling	525a
13:00–16:30	PT12 - Bridging Science and Policy: Delivering Impactful Presentations to Regulators	520e

POSTER SESSIONS 9:15–10:00 | 15:30–17:30

Poster sessions beyond those paired with oral sessions

- 2.08.P Finding Solutions to Salt Impacted Environments by Innovative Management and Risk Characterization
- 3.03.P General: Wildlife Toxicology, Ecology and Stress Response
- 4.12.P Environmental Forensics: Advances, Applications and Case Studies
- 4.18.P General: Chemistry and Exposure Assessment
- 5.08.P From Effect Models to Decisions: Integrating Effect Modeling into Regulatory Ecological Risk Assessment
- 5.11.P Global Trends Toward Environmental Risk Assessment for Pesticide Registration
- 5.15.P Recent Advances in Pesticide Risk Assessments for Non-Target Arthropods
- 6.03.P General: Engineering, Remediation and Restoration
- 7.08.P Managing Risk and Trust During Transformation of Environmental Risk Assessment Methods
- 7.10.P Success Stories on the Utilization of Long-term Contaminant Monitoring Data and Information to Assist in Decision Making and Strategic Planning
- 7.11.P Success Stories: Translating Science into Action to Effect Positive Change
- 8.04.P Circularity Under Climate Change - Effects on Adaption, Resilience and Ecosystem Services

POSTER SESSIONS 9:15–10:00 | 15:30–17:30

Poster sessions beyond those paired with oral sessions

- 1.07.P General: Environmental (Human and Ecological) Toxicology and Stress Response
- 2.10.P General: Aquatic Toxicology, Ecology and Stress Response
- 2.12.P Mercury in Fish in a Changing World: Trends, Drivers and Effective Risk Assessment and Management
- 3.04.P Knowledge Gaps, Research Needs and Ecological Considerations to Improve Avian Exposure Assessments
- 4.14.P Fate and Effects of Metals: Biogeochemical Perspective
- 5.03.P Advancing Human and Ecological Risk Assessment Using Microbial and Invertebrate Models
- 5.05.P Biologics in Agriculture: Improving Testing and Risk Assessment to Bring Biological Solutions to Growers
- 5.10.P General: Environmental (Human and Ecological) Risk Assessment
- 5.13.P One Health: The Detection Fate Effects Monitoring Management of Benthic/Pelagic Harmful Algal Blooms
- 5.17.P Wastewater Surveillance for Environmental Health Monitoring
- 5.18.P What's Next for Endangered Species Assessment of Plant Protection Products?
- 7.05.P General: Policy, Management and Communication
- 8.05.P Dealing with Fire: Post-Fire Monitoring to Assess Water Quality and Ecological Health

POSTER SESSIONS 9:15–10:00 | 15:30–17:30

Poster sessions beyond those paired with oral sessions

- 1.04.P Applications of Multi-Omics in Ecotoxicology
- 2.11.P Late-Breaking Science: Aquatic Toxicology, Ecology and Stress Response
- 3.05.P Late-Breaking Science: Wildlife Toxicology, Ecology and Stress Response
- 4.20.P Late-Breaking Science: Chemistry and Exposure Assessment
- 5.12.P Late-Breaking Science: Environmental (Human and Ecological) Risk Assessment
- 6.02.P Damage Assessment: Applied Toxicology for Injury Determination
- 6.04.P Late-Breaking Science: Engineering, Remediation and Restoration
- 7.06.P Late-Breaking Science: Policy, Management and Communication
- 8.06.P General: Systems Approaches
- 8.07.P Late-Breaking Science: Systems Approaches

TUESDAY PLATFORM SESSIONS 10:00–12:00

SESSION TITLE *Accompanied by a poster session	ROOM
4.10.T Emerging Contaminants in Our Changing World: Impacts of Climate Change, Wildfires and Policy*	513abc
5.09.T From Risk Characterization to Risk Reduction: Environmental and Human Health Risk Assessment and Mitigation Case Studies*	513def
2.09.T From Research to Action: The Potential of eDNA and eRNA in Ecotoxicology*	514abc
3.07.T.A Wildlife Ecotoxicology: Exposure, Accumulation and Effects*	515abc
2.01.T.A Assessing Contaminant Effects in Ecosystems With Multiple Stressors: From Laboratory to Field Studies, Modelling and Risk Assessment*	516ab
2.04.T Critical Minerals in a Warming World: Balancing Demand, Ecosystem Health and the Green Transition*	516c
1.01.T Advances in Environmental Quality Guidelines, Criteria, Objectives and Benchmarks*	516de
4.17.T From Tread to Watershed: How Tire Wear Particles and Chemicals Affect Aquatic and Terrestrial Ecosystems*	517a
4.23.T Pesticides in the Aquatic and Terrestrial Environment: Monitoring, Fate, Exposure and Ecological Effects*	517b
1.09.T.A Innovations in Environmental Toxicology to Advance the 3Rs	517c
4.02.T Advancing PFAS Forensics and Analysis: Integrating Source Differentiation, Analytical Developments and Regulatory Alignment*	517d

WEDNESDAY PLATFORM SESSIONS 10:00–12:00

SESSION TITLE *Accompanied by a poster session	ROOM
5.04.T Antimicrobials in the Environment: Chemistry, Fate and Ecotoxicity*	513abc
4.27.T Urban Infrastructure as a Vector for Emerging Contaminant Exposure*	513def
8.01.T Advancing Life Cycle Impact Assessment: Emerging Methods and System-Level Approaches*	514abc
5.01.T Advances in Bioaccumulation Science and Assessment: From Mechanisms to Predictive Tools*	515abc
2.05.T Ecotoxicology and Management of Bivalves*	516ab
2.14.T Technology-Critical Elements: From Sources, Exposure and Effects to Environmental Risk Assessment*	516c
4.09.T Elucidating the Mechanisms and Kinetics of Chemical Transformation Products*	516de
4.24.T Plastics and Plastic-Associated Contaminants as Environmental Mixtures: Monitoring, Fate, Effects and Interactions*	517a
5.07.T Centering Indigenous Knowledge in SETAC Science*	517b
5.06.T Bridging the Gap: Integrating AI, New Approach Methodologies and Novel Toxicity Endpoints for Next-Generation Risk Assessment*	517c
5.02.T.A Advances in the Ecotoxicology and Risk Assessment of PFAS*	517d

THURSDAY PLATFORM SESSIONS 10:00–12:00

SESSION TITLE *Accompanied by a poster session	ROOM
1.06.T Empirical and Theoretical Methods to Scale Contaminant Effects: Molecular Impacts to Organism Health*	513abc
4.22.T Occurrence, Fate and Effects of Contaminants Across Waste and Wastewater Systems*	513def
4.03.T Advancing Risk-Based Decisions Through Exposure and Dosimetry Modeling*	514abc
3.01.T Bidirectional Framework: Evaluating Exposure to Contaminants in Birds in Lab and Wildlife Studies*	515abc
2.03.T Conducting Toxicity Tests with Non-Standard Test Organisms or Conducting Non-Standard Toxicity Tests*	516ab
7.02.T Bridging Science and Public Understanding: Communicating Environmental Contaminant Risks*	516c
4.21.T Non-Targeted Analysis and High-Resolution Mass Spectrometry in Environmental Chemistry*	516de
4.05.T Beyond Detection: Advancing Passive Sampling for Exposure Characterization, Source Tracking and Risk Assessment*	517a
4.04.T.A Behavior and Fate of Legacy and Emerging Contaminants in Changing Arctic and Antarctic Environments*	517b
1.05.T Building Confidence in Omics Technologies*	517c
4.25.T Small Molecule, Big Questions: Precursors, Pathways and Planetary Reach of Trifluoroacetic Acid*	517d

TUESDAY PLATFORM SESSIONS 13:30–15:30

SESSION TITLE *Accompanied by a poster session	ROOM
8.08.T Proactive by Design: Alternatives Assessment in a Changing Global Chemical Policy Landscape*	513abc
1.14.T Protecting Soils–Linking Soil Ecology, Ecotoxicology and Ecological Risk Assessment*	513def
1.13.T Navigating the Nexus: Advancing Endocrine Disruptor Assessments Through Intersectoral Collaboration and Innovative Science*	514abc
3.07.T.B Wildlife Ecotoxicology: Exposure, Accumulation and Effects*	515abc
2.01.T.B Assessing Contaminant Effects in Ecosystems With Multiple Stressors: From Laboratory to Field Studies, Modelling and Risk Assessment*	516ab
8.09.T Prospective and Spatiotemporal Environmental Assessment for Energy and Transportation Transitions	516c
4.07.T Developing New Methods in Chemistry Which can be Used to Assess Environmental Impacts*	516de
4.15.T From Detection to Direction: Advancements and Best Practices for the Detection and Quantification of Micro- and Nanoplastics in Complex Media*	517a
3.06.T Plants at the Crossroads: Their Role in Ecotoxicology, Risk Assessment and Environmental Protection*	517b
1.09.T.B Innovations in Environmental Toxicology to Advance the 3Rs	517c
4.06.T Beyond the Usual Suspects: Exploring Emerging PFAS in Uncommon Systems*	517d

WEDNESDAY PLATFORM SESSIONS 13:30–15:30

SESSION TITLE *Accompanied by a poster session	ROOM
8.02.T Antimicrobial Resistance in the Environment: Drivers, Reservoirs, Transmission Pathways and the Science-Policy Interface*	513abc
1.10.T Innovative Approaches for Difficult-to-Test Substances and Unknown or Variable Composition, Complex Reaction Products or Biological Materials*	513def
6.01.T Case Studies and Approaches to Assessing Damages and Restoration from Oil and Chemical Releases*	514abc
3.02.T Cold-blooded in the Face of Pollution: Understanding and Mitigating Threats to Amphibians and Reptiles*	515abc
2.07.T Fate and Effects of Contaminants and Complex Mixtures in the Marine Environment*	516ab
1.15.T Selenium Ecotoxicology–Celebrating the 50th Anniversary of Bill Adams' PhD Dissertation*	516c
4.19.T Innovative Mass Spectral and Chromatographic Analyses Applied to Ecotoxicology and Environmental Monitoring*	516de
5.16.T Statistical Approaches in Environmental Toxicology: Recent Developments and Future Opportunities*	517a
8.03.T Challenges in Agricultural Systems: Balancing Food Production with Environmental Sustainability*	517b
1.02.T Advancing Molecular Tools and New Approach Methodologies for Next-Generation (Eco)Toxicology and Risk Assessment*	517c
5.02.T.B Advances in the Ecotoxicology and Risk Assessment of PFAS*	517d

THURSDAY PLATFORM SESSIONS 13:30–15:30

SESSION TITLE *Accompanied by a poster session	ROOM
1.03.T Advancing the Understanding and Test Methods for the Cross Species Extrapolation of Toxicities*	513abc
2.13.T Stormwater Runoff Impacts, Solutions and Innovative Research*	513def
4.26.T Transboundary and Legacy Pollutants in Aquatic Systems*	514abc
3.08.T Wildlife Toxicology: Evaluating Exposure and Potential Effects of Emerging and Legacy Contaminants*	515abc
2.02.T Assessing Toxicity in Water and Aquatic Sediments*	516ab
5.14.T Pharmaceuticals and Personal Care Products: Innovations in Risk Assessment, Regulation and Science*	516c
4.01.T Advancing Non-Targeted Analysis: Integrating Analytical Rigour, Informatics Innovation and Risk Assessment for Exposure Characterization*	516de
4.13.T Environmental Radioactivity: Advances in Biogeochemistry, Ecotoxicity and Ecological Risk Assessment*	517a
4.04.T.B Behavior and Fate of Legacy and Emerging Contaminants in Changing Arctic and Antarctic Environments*	517b
2.06.T Evolving Science in the Canadian Oil Sands Region*	517c
6.05.T Man, Environment and Microbes–Unravelling the Contributions of the Unseen Workforce in Sustainable Pollution Management*	517d

TUESDAY PLATFORM SESSIONS 16:30–18:30

SESSION TITLE *Accompanied by a poster session	ROOM
7.07.T Leaning in on Safety in an Era of Regulatory and Environmental Uncertainty	513abc
4.16.T From Persistent Organic Pollutants to Plastics, Great Lakes to Arctic: Honoring Liisa Jantunen*	516de
7.01.T Assessment of Endocrine Disrupting Chemicals: The Hazard vs. Risk Debate	517d

WEDNESDAY PLATFORM SESSIONS 16:30–18:30

SESSION TITLE *Accompanied by a poster session	ROOM
7.04.T From Research to Society: The Role of Foundations and Other Non-Profit Organizations in Advancing Ecotoxicology and Environmental Science	516ab
7.03.T Can I Trust Your Data? Data Quality Issues in Modern Ecotoxicology*	516c
7.12.T Who Safeguards Scientific Integrity? A Call to Collective Responsibility	516de
7.09.T Signal Fire–A Call to Action	517d

Program Committee

CO-CHAIRS



Valérie Langlois
National Institute of Scientific Research (INRS)



Magali Houde
Environment and Climate Change Canada (ECCC)

PROGRAM COMMITTEE MEMBERS

- Florence Pagé-Larivière, Environment and Climate Change Canada (ECCC)
- Raphaël Lavoie, Environment and Climate Change Canada (ECCC)
- Zofia Taranu, Environment and Climate Change Canada (ECCC)
- Julie Robitaille, Ministry of Environment, Fight Against Climate Change, Wildlife and Parks (MELCCFP)
- Jonathan Verreault, University of Quebec in Montreal (UQAM)
- Scott Hepditch, Stantec Inc.
- Lise Parent, Université TÉLUQ
- Melissa McKinney, McGill University
- Claude Fortin, National Institute of Scientific Research (INRS)
- Dominic Ponton, AECOM
- Frédérique Pelletier, AtkinsRéalis
- Jean Paquin, Sanexen
- Lou Paris, Sanexen
- Kevin Wilkinson, Université de Montréal
- Jonathan Challis, Agriculture and Agri-Food Canada

Meeting Supporters

PLATINUM SUPPORTER

SETAC Journals ET&C • IEAM

PLATINUM SUPPORTER

WELLINGTON LABORATORIES

GOLD SUPPORTER

GHD

GOLD SUPPORTER

WSP

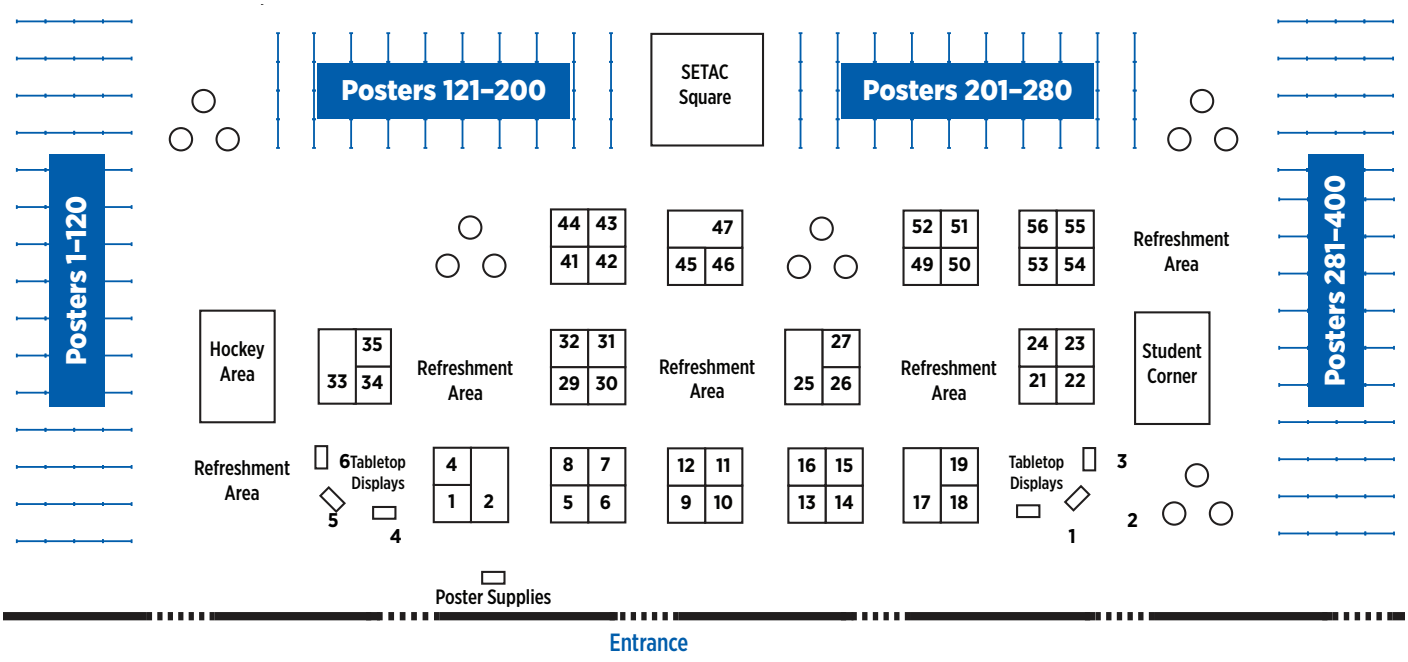
SILVER SUPPORTER

ACS Publications
Most Trusted. Most Cited. Most Read.

Exhibitors and Floor Plan

BOOTH NO.	EXHIBITOR LISTING
35	AGAT Laboratories
50	Agilent Technologies
54	ALS Global
15	AnalytiChem
5	Aqua Science
26	Azimuth Consulting Group Inc.
53	Baylor University
22	Brooks Rand Instruments
49	Cambridge Isotope Laboratories
Tabletop 5	Chapitre Saint-Laurent / EcotoQ
Tabletop 2	CIAPE-ICEDA (INRS)
18	Copperhead Environmental Consulting, Inc.
52	DSP-Systems
29	EA Engineering, Science, and Technology, Inc.
14	enviPath Limited
32	Exponent, Inc.
30	ExxonMobil
4	GEI Consultants, Inc.
56	Geosyntec Consultants
46	Great Lakes Environmental Center, Inc. (GLEC)
8	HESI Global
Tabletop 1	Institut national de la recherche scientifique
13	JRF Global
7	LGC Standards

BOOTH NO.	EXHIBITOR LISTING
16	Loligo Systems
25	Metals Data Center
Tabletop 6	MSDT-One Health Program, University of California, Davis
41	Nautilus Environmental Company, Inc.
Tabletop 4	NOAA National Mussel Watch Program - 40th Anniversary
44	Photon Medics
34	SCIEX
47	SETAC Journals
33	SETAC North America Endowment Fund
31	SGS AXYS Analytical Services Ltd.
11	Smithers
9	Spheros Environmental
21	Statera
24	Syngenta
12	TDI-Brooks / B&B Labs
19	Thermo Fisher Scientific
27	TrichAnalytics Laboratory
43	U.S. Geological Survey
45	UL Research Institutes' Chemical Insights
6	ViewPoint Behavior Technology
10	Waters Corporation
42	Wellington Laboratories LLC
1	Zef Scientific, Inc.



1. Environmental (Human and Ecological) Toxicology and Stress Response

Advances in Environmental Quality Guidelines, Criteria, Objectives and Benchmarks

1.01.T-01 Update of Québec Soil Quality Criteria

Viviane Dubois-Cote[1] and Nathalie Paquet[1] (1)Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs

In 1988, generic soil criteria imported from the Netherlands were published for the first time in a Québec government document. Modifications were subsequently made in 1998 and 2003. In 2023, the Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs (MELCCFP) undertook work to modernize the regulatory framework for contaminated soils and revise its soil quality criteria. This effort focuses on updating soil quality Criterion B (residential and sensitive institutional land use) and Criterion C (commercial and industrial land use).
The revision exercise aims to ensure that regulatory values reflect current science and knowledge, that Québec's values are consistent with those of other Canadian and North American jurisdictions, and that they protect public health.
The criteria revision work was carried out in collaboration with the Institut national de santé publique du Québec (INSPQ) and the ministère de la Santé et des Services sociaux (MSSS).
Before selecting replacement values, the MELCCFP conducted a review of the main approaches used in other jurisdictions for developing criteria based on the protection of human health. The methodological approaches were analyzed and evaluated according to various factors, and a scoring system was used to compare them. Subsequently, Québec's soil quality Criteria B and C values were compared with regulatory values from 23 jurisdictions. When a Québec criterion was found to be less conservative than the majority of those in other jurisdictions, a replacement value was selected. This value was then submitted to the INSPQ for review.
The INSPQ analyzed the proposed replacement values and provided feedback incorporating scientific considerations related to human health to support the MELCCFP in selecting its criteria. Following an evaluation of INSPQ's comments, the final replacement criteria were selected. To date, the process has enabled the revision of soil quality Criteria B and C values for metals and PAHs (polycyclic aromatic hydrocarbons).

1.01.T-02 From Bioavailability Models to Implementation Frameworks: Lessons From a California Case Study

Adam Ryan[1], Chris Beegan[2] and Robert Santore[3] (1)International Zinc Association (IZA), (2)California State Water Resources Control Board, (3)Barr Engineering Co.

Over the past two decades, bioavailability-based approaches for metals have become increasingly sophisticated and are now widely recognized as scientifically robust alternatives to traditional hardness-based water quality criteria (WQC). Biotic ligand models (BLMs) and multiple linear regression (MLR) models have improved characterization of metal bioavailability and toxicity across diverse water chemistry conditions and are increasingly being incorporated into regulatory frameworks. However, implementation guidance has not

advanced at the same pace as bioavailability science.

Historically, implementation challenges associated with water chemistry-dependent criteria were simplified through hardness-based assumptions. As bioavailability models incorporate additional toxicity-modifying factors, including pH and dissolved organic carbon, temporal and spatial variability in water chemistry become increasingly important considerations for regulatory application. Internationally, both effects-based and exposure-normalization approaches have been used to implement bioavailability-based criteria, highlighting the need for practical frameworks that translate bioavailability science into regulatory decision-making.

Using California as a case study, we examine the application of bioavailability-based criteria to multiple regulatory goals, including ambient water quality assessments, site-specific objectives, and permit-specific objectives. Monitoring datasets for copper and zinc were used to evaluate how temporal variability in water chemistry influences bioavailability-based criteria and the implications for regulatory implementation.

Results indicate that implementation approaches need to be tailored to specific regulatory goals within a given jurisdiction, even when based on the same underlying bioavailability model. These findings highlight the importance of developing practical implementation guidance alongside bioavailability models and provide insights relevant to jurisdictions considering broader adoption of bioavailability-based approaches for metals.

1.01.T-03 Assessment of the Sensitivity of Freshwater Species to Data-Poor Metals Pd, Pt and 226Ra in a Regulatory Perspective

Océane Hourtané[1], Tamzin El-Fityani[2], Kathleen McTavish[2], Rania Bouhkari[3], Flavie Desreac[1], Léna Guimard[1], Charlotte Lacroix-Durand[4], Julien Michaud-Valcourt[1], Edgar Perez[4], Catherine Proulx[5], Marc Amyot[3], Patrice Couture[1], Anne Cremazy[1], Richard Goulet[6], David Janz[4], Karsten Liber[4], Maikel Rosabal[7], Marilyne Stuart[8], Kim Racine[1], Kristin Mueller[9] and Claude Fortin[1] (1)National Institute for Scientific Research (INRS), (2)Environment and Climate Change Canada, (3)University of Montreal (UdeM), (4)University of Saskatchewan, (5)Kilgour & Associates Ltd., (6)Natural Resources Canada, (7)University of Quebec in Montreal (UQAM), (8)Canadian Nuclear Laboratories (CNL), (9)Ministry of Environment Quebec

Water Quality Guidelines (WQG) for the protection of aquatic life are meant to represent a threshold concentration below which there is a low likelihood of direct adverse effects on aquatic organisms. This information can support effluent discharge regulation and help to preserve the health of receiving ecosystems. Derivation of WQG relies on toxicity data obtained for a wide range of aquatic organisms. Such data is lacking for several metals, often referred to as data-poor metals. Our recent work has focused on filling these gaps for three elements of interest: two platinoids (Pd and Pt) as well as a radionuclide (226Ra). The former are mined in Canada and are highly mobilized by human activities due to their use, mainly in catalytic converters, but also in other sectors such as new technologies and health (e.g. anticancer drugs). The latter is a naturally occurring radionuclide and its environmental release is related to mining activities. Its high solubility, long half-life (~1600 years) and calcium analogy make 226Ra an isotope of concern for aquatic ecosystems. Thus, new toxicity data were generated for multiple Canadian freshwater species representing different trophic levels. This presentation compiles the results into Species Sensitivity Distribution (SSD) curves. While the determined threshold concentrations potentially affecting 5% of species (HC5) are mostly above measured environmental concentrations for these elements, they are still below the maximum reported concentrations. This highlights the

need for the implementation of new toxicity-based WQG. In the case of 226Ra, the chronic HC5 value is close to the current maximum concentrations allowed for grab samples under the Metal and Diamond Mining Effluent Regulations (MDMER; non-toxicity-based). Overall, the findings contribute to a better characterization of the risk associated with three data-poor elements in aquatic environments and will support the establishment of WQG for protection of aquatic life in Canada.

1.01.T-04 Deriving and Implementing an Ecologically Relevant Environmental Quality Standard for Aluminium in the UK: Utilising Existing Approaches and Remaining Challenges

Graham Merrington[1], Adam Peters[1], Charlotte Linley[1], STEPHEN LOFTS[2], Jay Bullen[3] and Mark Craig[4]
(1)wca environment Ltd., (2)United Kingdom Centre for Ecology & Hydrology (UKCEH), (3)Anglian Water, (4)Severn Trent Water

There has been a great deal of relatively recent activity driving towards the development of an ecologically relevant approach to the assessment of potential freshwater risks from aluminium. The importance of bioavailability on aluminium toxicity to aquatic organisms is well established. Bioavailability-based water quality standards for aluminium have been set in both the USA and Canada. In addition to an extensive review of recent literature the US and Canadian approaches have also been reviewed to determine how these might be used in a UK and European context.

Unfortunately, neither the Canadian or US approaches account for differences between algae (or plants) and invertebrates or fish in terms of their sensitivity to aluminium under different water chemistry conditions. Taking account of the sensitivity of algae and aquatic plants to aluminium requires extrapolation of the bioavailability model for algae for the approach to be applicable to most UK and European surface waters. The bioavailability normalisation approach used for the proposed standard for aluminium can be applied to 87% of sites in the UK.

The most sensitive region of the UK to aluminium is the South West due to low pH, low DOC concentrations, and low water hardness. The reference standard for aluminium in UK freshwaters is 54.1 µg L-1 total aluminium, expressed as an annual average. It is set for highly sensitive waters and is protective of 99% of UK waters.

As part of an ‘implementation assessment’ UK regulatory organisations require evidence that the approach and EQS to be used is delivery what is required in the field, i.e. is the EQS protective of ecological assemblages in the surface waters. This has been undertaken here using routine collected regulatory biological field data, in the case, for benthic invertebrates. Based on the analysis of field evidence the proposed UK EQS for aluminium is protective of local benthic invertebrate communities even in the presence of other additional stressors.

A key remaining challenge to the proposed approach is the need for further development and validation of bioavailability normalisation models. In the UK and Europe, bioavailability-based approaches require validation, with natural waters and dissimilar species to those used in the developmental tests. Currently for aluminium, these data do not exist.

1.01.T-05 The Development and Implementation of a Bioavailability-Based Environmental Quality Standard for Uranium Under the European Water Framework Directive

Graham Merrington[1], Iain Wilson[1], Lucy Kennelly[1], Melanie Trenfield[2], Andrew Harford[2], Adam Peters[1], STEPHEN LOFTS[3], Matti Leppanen[4], Johanna Järvistö[4], Karsten Liber[5], Markus Hecker[5], Andreas Aronsson[6], Nils Eriksson[7] and Torbjörn Karlsson[8] (1)wca environment Ltd., (2)Department of Climate Change, Energy, the Environment and Water (DCCEEW), (3)United Kingdom Centre for Ecology & Hydrology (UKCEH), (4)Finnish Environment Institute (SYKE), (5)University of Saskatchewan, (6)Andreas Aronsson Consulting AB, (7)Boliden, (8)Luossavaara-Kiirunavaara AB (LKAB)

In parts of Europe, including Sweden, natural background concentrations of uranium can exceed the existing Environmental Quality Standard (EQS). It is widely recognised that many biological and chemical factors can influence the behaviour and ecotoxicity of metals, including uranium, in surface freshwaters. Existing uranium EQS do not account for these factors, and so lack ecological relevance and can be both under and over protective of aquatic ecosystems.

In line with bioavailability model developments in recent years for regulatory application for other metals, such as copper, nickel, zinc, cobalt, we have developed the first chronic bioavailability model for uranium in freshwaters. The model development is based on the results of long-term toxicity tests with algae, aquatic invertebrates, and fish, which have investigated the influence of several toxicity modifying factors including pH, dissolved organic carbon (DOC) and hardness. The model has also been validated from tests on species not used in the development tests, but in the same respective taxa, in natural field-collected waters covering a wide range of water chemistry conditions. All these tests were specifically undertaken for this project as the existing chronic uranium ecotoxicity dataset is relatively limited and did not allow account to be taken of bioavailability.

In Europe, under the Water Framework Directive, national and Europe-wide EQS can be derived. For substances where account can be taken of bioavailability, both ecotoxicological effects data and water chemistry data for the area for which the EQS is being derived (i.e. a country or the whole of Europe). We have derived an EQSbioavailable for uranium for Sweden and for the whole of Europe, using the developed generalised bioavailability model, and water chemistry data from the last five years for >98,000 samples, from > 38,000 sites, for 32 countries.

To ensure the routine regulatory implementation of this approach, a simplified tool has been developed for uranium, that requires inputs of measured uranium, pH, hardness/calcium and dissolved organic carbon for the site under consideration. This approach provides an ecologically relevant metric to assess potential freshwater risks from uranium that can readily and routinely implemented into existing sampling and monitoring schemes, as well as use for site-specific and targeted assessments.

1.01.T-06 Derivation of an Ecological Effect-Based Trigger Value for Assessment of Androgenic Activity in Water

Agneta Oskarsson[1], Geeta Mandava[1] and Johan Lundqvist[2] (1)Swedish University of Agricultural Sciences, (2)Swedish University of Agricultural Sciences (SLU)

Androgens, in similarity to estrogens, pose serious threats to aquatic organisms by affecting reproduction and sexual development at concentrations as low as a few ng/L. The adverse effects are mediated via the androgen receptor, which is activated by natural and synthetic androgens, often occurring in complex mixtures. Effect-based monitoring by in vitro bioassay gives a comprehensive view of the total androgenic activity from known

and unknown chemicals. For assessment of potential ecological risks from androgens in the aquatic environment an effect-based trigger value (EBT) of 0.4 ng dihydrotestosterone equivalents/L (DHTeq/L) was derived from literature data on reproductive toxicity and determination of relative potencies in AR EcoScreen GR-KO M1 cells of DHT, androstenedione, methyltestosterone and 17β-trenbolone. Androgenic activity was determined in 782 samples of various water types collected in Sweden and the activities were compared with the derived ecological EBT. Androgenic activity was above EBT in almost all wastewater influents. Despite a treatment removal efficiency of 79–100%, androgenic activity was above EBT in 16% of effluents, 5% of recipients and 8% of surface water samples. This may be an underestimation as there is a risk of false negative results in samples where LOD is exceeding the EBT. Maximum androgenic activities in recipients, surface and raw water samples were 26.4, 11.2 and 3.27 ng DHTeq/L, respectively. Literature data show androgenic activities within the same order of magnitude as in the Swedish samples. Mainly unknown chemicals contribute to the androgenic effects in water, which clearly shows the need of effect-based methods and an EBT for environmental monitoring and assessment of androgenic effects.

Advances in Environmental Quality Guidelines, Criteria, Objectives and Benchmarks

1.01.P-Tu010 Assessing the Ecological Relevance of Freshwater European Environmental Quality Standards for Copper Using Field-Collected Biological Data

Graham Merrington[1], Iain Wilson[1], Adam Peters[1], Tara Miller[2] and Erin Smith[3] (1)wca environment Ltd., (2)INTERNATIONAL COPPER ASSOCIATION, (3)Copper Alliance

Water Quality Guidelines (WQG) and Environmental Quality Standards (EQS) are derived using data from laboratory ecotoxicity test data, mostly on cultured organisms under very controlled conditions and dosing. However, WQG and EQS are used in the field to assess risks to aquatic ecosystems through comparison to measured concentrations in surface waters. How do we know that a laboratory data-derived guideline or standard is protective of our aquatic ecosystems, and not over or under protective?

This poster will demonstrate the use of an approach that has used field-collected benthic macroinvertebrate taxa from routine UK regulatory monitoring, that are responsive to increasing bioavailable copper exposures and apply a “limiting function” approach to derive EC10 values for declines in the total abundance of these taxa. These field data provide a direct indication of ecological relevance of existing and proposed European copper EQSs.

Utilising these types of data to make this assessment, and by using the copper Biotic Ligand Model to correct the copper exposures, it is possible to evaluate the margins of safety under real, ecologically relevant exposure conditions for the copper EQS.

In Europe, EQS are legally binding limits – effectively regulatory ‘bright-lines’, and we will demonstrate the importance of field-based validation of EQSs as part of broader implementation assessment, using copper as an example.

1.01.P-Tu011 Investigating Approaches To Derive Screening Prop 65 Safe Harbor Levels for Chemicals Regulated As Toxic to Reproduction

Meredith Frenchmeyer[1] and Norman Forsberg[1] (1)Arcadis

Background
Although over 900 chemicals are regulated under California's Proposition 65 (Prop 65), OEHHA provides Safe Harbor Levels (SHLs) for less than half. This data gap poses a technical challenge to businesses operating in California. Commonly, the process of reviewing a chemical's toxicological database and determining the endpoint-specific point of departure (POD) requires the largest investment of resources. An approach to calculate screening SHL values that balance Prop 65's regulatory requirements, public health-protection, and SHL development costs is investigated.

Approach
This investigation uses substances that have both Prop 65 maximum allowable dose levels (MADLs) for reproduction toxicity and U.S.-based regulatory toxicity reference values. Screening SHL values are calculated using existing regulatory toxicity reference values or their PODs, which are compiled from the following sources:

- California (e.g., DTSC's Human and Ecological Risk Office Note 10)
- Federal (e.g., U.S. EPA's Integrated Risk Information System and Provisional Peer-Reviewed Toxicity Values, and the ATSDR's Minimal Risk Levels)

The reference toxicity values and their PODs are used to calculate screening SHLs by considering requirements specified in Title 27 Cal. Code of Regs §25803. The existing regulatory reference toxicity values are not necessarily derived based on the same critical endpoint that OEHHA used as the basis of a chemical's Prop 65 listing (e.g., developmental toxicity); however, they are hypothesized to be derived using PODs that are at least as sensitive as those associated with the critical effect for which the chemical is regulated under Prop 65.

Results
Developing screening SHLs is a cost-effective approach to fill existing data gaps. Providing direct comparisons of screening SHLs calculated with available regulatory toxicity reference values and OEHHA provided SHLs provides context to understand the magnitude and directionality of bias between the two approaches. Scatterplot(s) will visually display the correlation between screening SHLs and OEHHA's SHLs. Instances where the screening SHLs are substantially under protective compared to OEHHA's SHLs will be highlighted and discussed. Conclusions will summarize the magnitude of difference between the two approaches, additional considerations for deriving screening SHLs, and implications for regulated businesses that choose a screening SHL approach in the absence of OEHHA provided SHLs.

1.01.P-Tu012 Exploring Stated and Implied Protection Goals for Aquatic Receiving Environments

Ryan Hill[1], Gary Mann[1] and Guy Gilron[2] (1)Azimuth Consulting Group Inc., (2)Borealis Environmental Consulting Inc.

Ecological protection goals for aquatic receiving environments are stated or implied in numerous contexts including protocols for development of generic water quality guidelines; guidance documents for permitting of

effluent discharges including establishment of initial dilution zones; and guidance for development of biological monitoring programs to detect potential adverse effects. We review various guidance documents, primarily but not limited to those used in British Columbia. We identify some ambiguity about protection goals and their application based on current guidance and our experience. Discussion focuses on (1) clarifying the application of protection goals in the context of decision-making for discharge authorizations, and (2) exploring the appropriate role of generic water quality guidelines in supporting discharge authorizations.

1.01.P-Tu013 Screening Performance of the British Columbia Dissolved Copper Water Quality Guideline Under Ambient Water Chemistry Conditions

Jeremy Jackson[1] (1)Stantec Consulting Ltd., Burnaby, British Columbia, Canada

The British Columbia (BC) dissolved copper water quality guideline for the protection of freshwater aquatic life is derived using a biotic ligand model (BLM). In routine screening applications, a simplified implementation of the BLM is typically applied that incorporates pH, dissolved organic carbon (DOC), and hardness as toxicity modifying factors, while the full BLM accounts for a broader suite of water quality parameters. Although the guideline is widely used in regulatory screening and environmental assessment, its empirical screening performance under ambient water chemistry conditions has not been evaluated at a provincial scale.

This study assesses the screening performance of the BC copper guideline using a large, publicly available surface water monitoring dataset representing minimally impacted receiving environments across BC. Site- and sample-specific guideline values were calculated using measured water chemistry, and guideline exceedances were evaluated in terms of frequency, magnitude, and recurrence. Exceedance patterns were examined across water chemistry regimes to distinguish guideline sensitivity driven by natural geochemical conditions from elevated copper concentrations. Parallel analyses using the BC nickel BLM were conducted to evaluate whether observed performance characteristics are specific to copper or reflect broader features of BLM based metal guidelines.
In addition, the study examines the influence of guideline implementation practices—including the use of simplified chemistry inputs, lookup tables, conservative rounding, and minimum guideline thresholds—on calculated guideline values and apparent exceedance rates under routine screening applications.

By characterizing guideline performance across a wide range of ambient water chemistries, this work provides empirical context for interpreting copper guideline exceedances in background environments and supports informed application of chemistry dependent guidelines in screening level assessments

1.01.P-Tu014 Assessment and Selection of a New Perfluorooctane Sulfonate Reference Dose and Relative Source Contribution As the Basis for Michigan's Fish Consumption Screening Values

Lisa Fischer[1] (1)Michigan Department of Health and Human Services

The Michigan Department of Health and Human Services (MDHHS) issues fish consumption guidelines based on Fish Consumption Screening Values (FCSVs), which are developed for several contaminants, including perfluorooctane sulfonate (PFOS). In 2014, MDHHS established FCSVs for PFOS using an interim reference

dose (RfD) of 14 nanograms per kilogram per day (ng/kg-d) based on thyroid and cardiovascular endpoints and used a Relative Source Contribution (RSC) of 100%. Since 2014, several federal and state agencies released new or updated toxicity values for PFOS showing adverse effects at lower values than previously and several routes of exposure. Based on the best available science and the subsequent need for an updated RfD and RSC, MDHHS updated its FCSVs for PFOS in 2025.

Upon reviewing the recent literature and evaluation of published toxicity values, MDHHS concluded that using the Michigan Science Advisory Workgroup's RfD of 2.89 ng/kg-d PFOS to update the FCSVs would be protective of human health. The selected RfD was based on immunological endpoints as both human and animal studies have reported immunological effects as the critical health endpoint, and that these effects occur at similar doses as other health endpoints such as hepatic, cardiovascular, and developmental effects.

Following guidance from the United States Environmental Protection Agency, an RSC between 20% and 80% was considered since exposure to PFOS occurs from multiple sources besides fish consumption. The National Health and Nutrition Examination Survey 2017-2018 geometric mean for PFOS in human serum was used to represent "background" exposure to PFOS across multiple exposure pathways and was divided by the selected RFD to determine the percentage of exposure not due to fish consumption. The remaining percentage was used to establish the RSC due to fish consumption, which was 80%.

Overall, updating the RfD and RSC led to FCSVs for PFOS that are approximately 6 times lower than before, with a threshold for issuing a Do Not Eat advisory being lowered from 300 to 49.6 parts per billion. This led to an increase in fish consumption guidelines in Michigan that are driven by PFOS. As of 2026, approximately 24% of the fish consumption guidelines in Michigan are driven by PFOS.

Advancing Molecular Tools and New Approach Methodologies for Next-Generation (Eco)Toxicology and Risk Assessment

1.02.T-01 Untargeted Plasma Proteomics To Identify Sublethal, Chronic Effects of Artificial Sweeteners on Rainbow Trout

Adam Point[1], Theresa Warriner[1] and Denina Simmons[1] (1)Ontario Tech University

Artificial sweeteners are sugar substitutes added to foods, beverages, and various pharmaceutical and personal hygiene products. Sucralose and saccharin – two highly used artificial sweeteners – are not metabolized by humans and are poorly removed during wastewater treatment, resulting in their widespread release to environmental waterbodies. Constant discharge, increasing usage, and environmental persistence of artificial sweeteners yield worsening chronic exposure conditions for aquatic organisms. Artificial sweeteners are not acutely toxic; however, they represent a potentially significant threat to aquatic life because of their ubiquity and understudied chronic effects. We exposed adult rainbow trout (Oncorhynchus mykiss) to 200 µg/L aqueous sodium saccharin or sucralose for 28 days followed by label-free untargeted proteomics utilizing liquid chromatography and tandem mass spectrometry to identify biomarkers in blood plasma. Of the 252 protein groups detected, both sweeteners caused statistically significant changes in protein abundances versus control trout, with 76 and 72 proteins affected by saccharin and sucralose, respectively. Saccharin exposure primarily

caused a decrease in protein abundances (95% of significantly affected proteins) while sucralose exposure mainly caused an increase in protein abundances (76% of significantly affected proteins). Twenty-six proteins were affected by both sweeteners, with 19 (73%) showing the same direction of change for both chemicals relative to the control group. Translating these protein alterations into their related biological functions, preliminary results suggest that both sweeteners affect the neuromuscular system of rainbow trout. Additionally, saccharin exposure altered proteins associated with increased oxidative stress and sucralose exposure affected several proteins related to the complement system, suggesting immune system impacts. While our study included only two of the several common commercial sweeteners at a concentration exceeding typical environmental levels, these results indicate that artificial sweeteners may cause harmful chronic effects on aquatic organisms and further research is warranted.

1.02.T-02 Linking Transcriptomic NAMs With Traditional Ecotoxicity Endpoints Using Data From Salt Exposures

Olivia Torano[1], Weichun Huang[1], Morgan Hu[1], Nora Mosch[1], Meagan Bell[1], David Bencic[1] and Adam Biales[1]
(1)U.S. Environmental Protection Agency (US EPA)

The number of chemicals entering commerce greatly outpaces the resources available to assess their potential risk using traditional toxicity assessment methods. To address this challenge, there has been an emphasis on the development of new approach methods that can quickly generate data to guide the evaluation of chemical risk. Among these NAMs, transcriptional points of departure (tPODs) have been identified as a potentially viable alternative to traditional methods; however, to date there is no consensus on best practices. As such, we evaluated parameters for the derivation of tPODs in larval fathead minnow for three geochemical salts NaCl, CaCl2, and KCl. This system was selected for tPOD optimization as relies on chemicals with extensive effects characterization that pose minimal hurdles in terms of exposure, while also preserving the inherent biological variability expected using an in vivo system. In this study the mortality, growth, and reproduction endpoints used to derive USEPA's chloride standard and subsequently published traditional toxicity endpoints of associated cations were used to assess the concordance between traditional apical endpoints and transcriptomic new approach methods (tNAMs). Bulk RNAseq was collected from 5-day post fertilization fathead minnow larvae after 24-hour NaCl, CaCl2, and KCl exposures. Gene expression changes from control were tested with DESeq2 and benchmark dose (BMD) modeling was done to derive transcriptomic points of departure (tPODs), the points at which a concerted molecular response occurs. BMD modeling was done in BMDExpress3 using several sets of parameterizations. Optimizing BMD modeling methods is a point of active research at USEPA and while differing methods can have a large influence on derived tPODs, this study found similar points of departure across methods. tPODs for all three salts fell below 24-hour LC50 values, and NaCl and KCl tPODs fell between subchronic NOEC and LOEC values reported by Pickering et al., 1995. To further investigate methods of tPOD derivation, genes associated with salt specific tPODs were screened for relevancy with known modes of action of salt toxicity. Both salt relevant and general stress response genes were found, highlighting the need for further methodological refinement in BMD modeling and gene functional analysis, especially in ecologically relevant species such as fathead minnow.

Disclaimer/Disclosure: The views expressed in this abstract are those of the author(s) and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency.

1.02.T-04 Leveraging Machine Learning and Cell Painting To Predict Mitochondrial Modes of Action in Agrochemical Safety Screening

Gyan Harwood[1], Jiaqi Xu[1], Eric Sherer[1] and Moriah Zielinski[1] (1)Corteva Agriscience

The rigorous safety assessment of new agrochemicals requires efficient methods to identify undesirable modes of action (MoA), such as those affecting mitochondrial function. This study presents a machine learning (ML) framework for high-throughput prescreening of mitochondrial toxicity. We integrated morphological profiles from cell painting assays with molecular structure descriptors to predict four distinct mitochondrial MoAs for a dataset of 230 compounds. Our approach utilized a variety of single and ensemble machine learning models to: (1) identify uncouplers, (2) identify mitochondrial electron transport chain (ETC) inhibitors, (3) differentiate between mitochondrial ETC complex I, II, and III inhibitors, and (4) classify multi-site inhibitors and negative controls. By combining cell painting and chemical structure data (i.e., early fusion), our models achieved robust performance for the primary classification goals, with a Gradient Boosting model yielding a recall of 0.86 and balanced accuracy of 0.80 for uncouplers, and a soft voting ensemble achieving a recall of 0.87 and balanced accuracy of 0.83 for Mitochondrial ETC inhibitors. The models also successfully differentiated mitochondrial ETC subtypes. This work demonstrates that integrating morphological and chemical data provides a powerful, efficient, and reliable screening tool to prioritize compounds and de-risk agrochemical discovery pipelines.

1.02.T-05 Incorporation of New Approach Methodologies (NAMs) in Chemical Risk Assessment: Molecular Dynamics Simulations of Chemical Interactions With Lung Surfactant Monolayer

Rayaan Kazim Rizvi[1], Ridwan Sulaimon[1], Gilles Peslherbe[1] and Xianming Zhang[1] (1)Concordia University

Modern chemical risk assessment and regulatory frameworks are increasingly shifting toward New Approach Methods (NAMs). Within this paradigm, in silico approaches such as molecular dynamics (MD) simulations enable detailed, molecular-level characterization of the interactions between xenobiotics and biological or environmental interfaces. In this study, we employ MD simulations to address a critical knowledge gap regarding the inhalation exposure and respiratory fate of tire-derived contaminants. We simulated the transport and thermodynamics of 6PPDQ across a biomimetic, mixed dipalmitoylphosphatidylcholine (DPPC) and dipalmitoylphosphatidylglycerol (DPPG) lung surfactant monolayer. To capture the dynamic respiratory cycle, both expanded and compressed monolayer configurations were evaluated, mimicking inhalation and exhalation states, respectively. Potential of Mean Force (PMF) profiles reveal that 6PPDQ preferentially interacts with the lipid carbonyl region resulting in minimum free energy therein. The compressed film exhibiting a lower free energy and a stronger thermodynamic retention capacity than the expanded film. Concurrently, diffusivity and resistance profiles indicate a marked reduction in 6PPDQ mobility within the dense lipid region, an effect significantly more pronounced in the compressed state. A specific cation-Pi interaction between 6PPDQ and tertiary amine group of DPPC was observed and can potentially affect the structure of the lung surfactant monolayer. These findings demonstrate that the lung surfactant monolayer functions as a physical reservoir for 6PPDQ, potentially delaying clearance and modulating its bioavailability to underlying lung epithelial cells. Finally, leveraging the MD-derived partitioning and diffusion coefficients, we developed a multiscale mass transfer model that mathematically links ambient air concentrations directly to cellular exposure levels. This work highlights the utility of integrating molecular simulations with macro-scale transport models to advance predictive inhalation exposure within NAM frameworks.

1.02.T-06 Development of a Protein Marker Panel To Assess Chemical Toxicity Mechanisms and Effects in Fish Cell Lines

Mihai-Ovidiu Degeratu[1], Severin Ammann[1], Jessica Bertoli[1], Marion Revel[1], Kristin Schirmer[2], Colette vom Berg[2] and Ksenia Groh[2] (1)Eawag - Swiss Federal Institute of Aquatic Science and Technology, (2)Swiss Federal Institute of Aquatic Science and Technology (Eawag)

Fish cell line-based assays represent valuable animal-free alternatives for predicting chemical toxicity and have already been successfully applied to assess acute toxicity in fish. To advance the prediction of chronic toxicity endpoints, such as fish growth reduction, gaining a deeper mechanistic understanding of underlying molecular changes is essential. While a number of toxicity-relevant gene and metabolite panels have been developed, protein-level sets are lacking so far, although proteins could offer a stronger connection to phenotypic outcomes.

Here, we present a tentative panel of protein markers expected to enable key mechanistic insights into chemical toxicity in fish cell lines. The panel contains 120 evolutionary-conserved candidate proteins identified based on literature review as representative of diverse molecular toxicity mechanisms and effects. Multiomics analysis (transcriptomics and global proteomics) of the zebrafish (Danio rerio) embryonic cell line PAC2, recently performed by our group, confirmed the baseline expression of these targets.

To refine the proposed panel, we developed a mass spectrometry-based targeted proteomics workflow to quantify marker responses in proliferating PAC2 cells exposed to six reference chemicals with distinct mechanisms of action: thapsigargin (endoplasmic reticulum stress via increased cytosolic calcium ion levels), tunicamycin (endoplasmic reticulum stress via inhibition of protein glycosylation), diethyl maleate (oxidative stress), nocodazole (cytoskeleton structure disruption), 2,4-dinitrophenol (oxidative phosphorylation disruption), and perfluorononanoic acid (lipid metabolism disruption). Each chemical is assessed at four timepoints (4, 24, 48, and 120 h) following exposure to three concentrations corresponding to ~0% (non-toxic), ~25% and ~50% of cell viability loss. This experimental design enables the investigation of the temporal progression of concentration-dependent molecular effects leading to toxicity.

Analysis of thapsigargin and diethyl maleate data confirmed the efficiency and sensitivity of the developed targeted proteomics method as well as the chemical responsiveness of candidate protein markers. The complete dataset will enable comparative analyses of mechanistic relevance and robustness to identify the most informative and reliable protein markers for inclusion on the final zebrafish panel, which can later be extended to cover other fish species of ecotoxicological interest.

Advancing Molecular Tools and New Approach Methodologies for Next-Generation (Eco)Toxicology and Risk Assessment

1.02.P-We240 In Vitro Effects-Based Monitoring of Liquid Impoundment Facility Contaminants Using Avian Liver Cell Spheroids

Dania Abu Khajil[1], Jason O'Brien[2], Doug Crump[2], Tasnia Sharin[2], Christy Morrissey[3], Lukas Mundy[2], Suzanne Chiu[4] and John Headley[5] (1)Carleton University, (2)Environment and Climate Change Canada (ECCC),

(3)University of Saskatchewan, (4)Environment and Climate Change Canada, (5)Environment of Climate Change Canada

Liquid impoundment facilities (LIFs) in the Athabasca oil sands region contain complex mixtures of contaminants, such as naphthenic acids (NAs) and polycyclic aromatic compounds (PACs), which pose potential risks to wildlife, including birds. In vitro effects-based monitoring offers a cost-effective, animal-alternative approach to evaluate the effects of chemicals and complex mixtures. In this study, cytotoxicity, mRNA expression and biochemical endpoints were measured in leghorn male hepatoma (LMH) spheroids exposed to extracts derived from polar organic chemical integrative samplers (POCIS) and polyethylene (PE) samplers, which accumulate NAs and PACs, respectively. Samplers were deployed for two weeks at 12 locations within LIFs within the Athabasca oil sand region. The goal is to evaluate in vitro bioactivity among sites to determine relative potency of extracts and assess whether biological activity correlates with chemical composition. Concentrations of NAs and PACs in POCIS and PE samplers were determined using gas chromatography-mass spectrometry and ranged from 9,500 to 26,000 ng/sample and 7,300 to 204,000 ng/sample for NAs and PACs, respectively. Cytotoxicity was assessed using the CellTiter-Glo assay to determine the highest non-cytotoxic concentrations, which were selected for gene expression analysis using a custom chicken RT² profiler array (comprising 43 target genes and 5 controls). Based on the gene expression results, follow-up biochemical assays including EROD, CYP3A, and TTR were conducted. Ongoing work will further investigate these responses using whole-transcriptome ribonucleic acid sequencing (RNAseq) to characterize broader molecular effects and identify novel biomarkers associated with exposure to LIF contaminant mixtures. This study integrates chemical characterization, biochemical assays targeted/non-targeted toxicogenomics in an animal-free cell model. The results will improve understanding of the biological activity of complex contaminant mixtures and support the development of cost-effective, animal-alternative approaches for identifying and prioritizing hotspots within the oil sands region.

1.02.P-We241 Bacterial Components and Benzoic Acid Modulate Inflammatory and Airway Remodeling Pathways in Asthmatic Lung Cell Co-Cultures

Matthew Day[1], Rébecca Gagnon[2], Fiona Situ[1], Celeste Pina-Leblanc[1], Catherine Girard[3] and Élyse Caron-Beaudoin[1] (1)University of Toronto Scarborough, (2)Université du Québec à Chicoutimi, (3)Université Laval

Asthma, affecting over 4.6 million Canadians, is driven by airway restructuring and inflammation via T2-high and T2-low pathways. Air pollutants and microbial products may contribute to asthma exacerbations, yet their effects on epithelial–fibroblast interactions remain poorly understood.

This study investigates gene expression in T2-high and T2-low inflammation, antioxidant activity, and angiogenesis in monocultures and co-cultures of primary asthmatic lung fibroblasts and epithelial cells following 24-hour exposure to a volatile organic compound metabolite – benzoic acid (0.04µM, 0.4µM), and two components of bacterial cell walls – lipopolysaccharide (LPS, 1µg/mL) and peptidoglycan (PGN, 3.3µg/mL). Expression of inflammatory and remodeling markers (solute carrier family 26 member 4, interleukin 6 (IL-6), interleukin 8 (IL-8), thymic stromal lymphopoietin, fibroblast growth factor 2 (FGF-2)) were assessed using digital PCR. Antioxidant activity (total antioxidant activity, superoxide dismutase, catalase) and angiogenesis (vascular endothelial growth factor) were assessed via ELISA assay. Exposure conditions were compared to either a dimethylsulfoxide (0.5%) or phosphate-buffered saline (0.5%) control.

Benzoic acid exposure (0.04µM, 0.4µM) significantly increased T2-low inflammatory marker IL-8 by 262% and 211% compared to control in epithelial cells in monoculture and co-culture, respectively. Compared to control, exposure to bacterial components (LPS, 1µg/mL; PGN, 3.3µg/mL) significantly increased T2-low inflammatory marker IL-6 in fibroblast monocultures by 1844% and 944%, while IL-8 expression increased by 1771%, 944%. Compared to control, IL-8 expression in epithelial cells significantly increased by 320% in monocultures exposed to LPS, and by 1524% in co-culture exposed to PGN. Compared with controls, FGF-2 expression significantly increased by 143% in LPS exposed epithelial cells in co-culture. Neither benzoic acid nor bacterial components had significant effects on antioxidants or angiogenesis.

Co-culture exposures often exhibited reduced inflammatory responses in fibroblasts and increased responses in epithelial cells, suggesting intercellular communication between epithelial and fibroblast cells may moderate asthmatic inflammation. In response to VOC metabolite and bacterial exposure, genes involved in airway remodelling were increased exclusively in epithelial cells in co-culture suggesting a key role controlling airway structure in asthma.

1.02.P-We242 Do per- and Polyfluoroalkyl Precursors Impact Embryo Development in Zebrafish and Walleye?

Molly Dobrik[1], Erin Ussery[2] and Joanna Wilson[1] (1)McMaster University, (2)Environment and Climate Change Canada (ECCC)

Precursors of Per- and polyfluoroalkyl substances (PFAS), such as perfluorobutane sulfonamide (FBSA) and 5:3-fluorotelomer carboxylic acid (5:3-FTCA), are released into the environment from firefighting foams, wastewater treatment plants, and landfills. PFAS precursors are a concern because they can transform into stable PFAS compounds through biotic and abiotic processes. FBSA and 5:3-FTCA are high priority for chemical toxicity screening as little is known about their toxicity. Canada has legislated a reduction of vertebrates in chemical toxicity testing. One possible new approach method is the Fish Embryo Acute Toxicity (FET) which exposes zebrafish (Danio rerio) embryos to a chemical for 96 hours to determine lethality. However, zebrafish are not native to Canada, which may limit their applicability and use to Canadian environmental regulations. Therefore, adaptation of the FET test to native species is necessary. Native Canadian species of interest are fathead minnow (Pimephales promelas) and rainbow trout (Oncorhynchus mykiss) as they are frequently used for toxicity testing in Canada. Walleye (Sander vitreus) is a valued species for both sport fisherman and Indigenous communities. My research goals are to determine the comparative sensitivity between these three native species and zebrafish to PFAS precursors and if there are differences in sensitivity across embryonic and larval life stages. The comparison of sensitivities will determine if adaptation of the FET test to these native species is necessary. I predict cold water species will be more sensitive than warm water species. At current, walleye were exposed to FBSA and 5:3-FTCA and assessed for behavioural and developmental endpoints. Exposure demonstrated FBSA and 5:3-FTCA have no impact on survival, heart rate, or developmental abnormalities. At present, zebrafish exposures are being conducted. Zebrafish embryos and larvae will be sampled for the EcoTox Chip to evaluate gene expression in biological pathways associated with chemical exposure and stress responses in the embryo and larval stages. My project will support relevant, scientifically informed decisions regarding the environmental risk of PFAS in Canadian aquatic ecosystems and the development of new approach methods.

1.02.P-We243 Identification and Characterization of Covalent Adduct Formation of Fluorotelomer Unsaturated Carboxylic Acids With Histone Proteins

Robert Letcher[1] and Shaogang Chu[2] (1)Environment and Climate Change Canada (ECCC), (2)Environment and Climate Change Canada

Fluorotelomer unsaturated carboxylic acids (FTUCAs) are intermediate compounds formed during degradation and metabolism of fluorotelomer-based compounds which are all classified as per- and polyfluoroalkyl substances (PFAS). FTUCA formation is an important conversion process and is crucial to the toxicity of fluorotelomer-based compounds. Histones are well conserved proteins of critical importance in maintaining appropriate gene expression. The N-terminal tails of histones can undergo a variety of post-translational modifications (PTMs), such as acetylation, phosphorylation, methylation, and ubiquitination. Disruption in the homeostatic on/off rates of histone PTMs often leads to aberrant gene expression. Adductomics is a relatively new "omics" research field that focuses on the formation and prevalence of DNA, RNA, and protein adducts whose formation is induced by endogenous and exogenous (xenobiotic) chemicals in biological systems. Adducted proteins are usually stable and may accumulate during the lifespan of a protein, resulting in long duration of deleterious effects. Identifying protein adducts is critical for understanding molecular mechanisms of toxicology of contaminants, e.g. cancer. This study investigated non-enzymatic covalent modifications (NECMs) in vitro in histone proteins of calf thymus and Human H3.3 with 6:2 and 8:2 FTUCAs, PFOA and PFOS. Peptides from the protein digestion were analyzed by ultra-high performance liquid chromatograph-Q-Exactive orbitrap mass spectrometry (Thermo Fisher Scientific). Q-Exactive MS was performed in (ESI (+)) mode, scanning from 150–2000 m/z and operated in the data dependent acquisition fragment analysis mode (full MS/dd-MS2) for histone-adduct identification. All spectra of PFAS modified peptides were characterized by their isotope distribution (M+1, M+2 and M+3) in full scan mode and MS/MS fragment in the dd-MS2 mode. Using bottom-up proteomic method, adduct chemical groups and the location of specific protein adduction sites were identified. Twelve adducted sites were identified from samples of 6:2 FTUCA (or 8:2 FTUCA) incubated with histone proteins, which included H2A, H2B, H3 and H4, after proteolytic digestion. No covalent adducts were detectable in PFOA or PFOS treated assays. Longer-term FTUCA exposure in organisms may result in deleterious effects that may be toxicologically relevant. Adducts could also be used as and/or lead to biomarkers of fluorotelomer-based PFAS exposure.

1.02.P-We244 Comparative Evaluation of Vascular Developmental Toxicity Induced by Phthalates and Alternative Plasticizers Using Zebrafish Embryos: Toward an Omics-Based AOP Framework

Kyunghee Ji[1], Da Yeong Lee[1], Seunghyun Kim[1] and Sung Ho Hwang[1] (1)Yongin University

Phthalates are widely used in consumer products and are frequently detected in environmental and biological samples. Concerns have increased regarding developmental toxicity and vascular disruption caused by these chemicals, whereas toxicological information on alternative plasticizers remains limited. Angiogenesis disruption has been suggested as an early indicator of developmental toxicity.
This study evaluated vascular developmental toxicity induced by phthalates and alternative plasticizers using zebrafish embryos and aimed to establish an omics-based framework for adverse outcome pathway (AOP) development. Zebrafish embryos were exposed for 96 h post-fertilization to di(2-ethylhexyl) phthalate (DEHP), di(2-ethylhexyl) terephthalate (DEHTP), diisobutyl phthalate (DiBP), and diisobutyl adipate (DiBA).

Developmental endpoints, vascular morphology, and molecular responses related to oxidative stress, angiogenesis, cardiac function, inflammation, and apoptosis were analyzed.
Preliminary results demonstrated developmental and vascular alterations in zebrafish embryos. DEHP exposure increased pericardial area and reduced blood flow velocity, indicating cardiovascular dysfunction, whereas DEHTP showed weaker cardiovascular effects but significantly reduced body length. Exposure to selected plasticizers altered expression of genes associated with oxidative stress and cardiac function, including nppa, bcl2a, and casp3b. Comparative analyses suggested that alternative chemicals may not exhibit lower developmental toxicity than conventional compounds.
In the ongoing phase of this project, transcriptomics, metabolomics, epigenomics, and lipidomics approaches will be integrated to identify molecular initiating events and key events associated with vascular developmental toxicity. An AOP-based scoring framework will also be developed to prioritize chemicals according to vascular disruption potency.
This study provides mechanistic insight into vascular developmental toxicity induced by emerging environmental contaminants and contributes to alternative toxicity assessment frameworks for chemical prioritization and regulatory science.

Disclaimer/Disclosure: This study was supported by the National Research Foundation of Korea (NRF; Project no. RS-2026-25482321).

1.02.P-We245 New Faces, Same Threat: Metabolic Toxicity of BPA Safer Alternatives in Human Cell Models

Rafia Afroze Rifa[1] and Ramon Lavado[1] (1)Baylor University

Bisphenol analogs are widely adopted as alternatives to bisphenol A (BPA) in the production of plastics, coatings, and resins. Although often marketed as safer options, several of these compounds have been linked to adverse health outcomes involving oxidative and metabolic stress. This study evaluated the cytotoxicity of seven bisphenol analogs (BPS, BPF, BPAF, BPP, BPAP, BPB, BPE) in eight human cell lines representing key organs. BPE was most toxic in Caco-2 intestinal cells (EC50 = 0.2 μM), while HepaRG (liver) and HEK293 (kidney) cells were highly resistant to BPS (EC50 > 1000 μM). BPAF, BPP, and BPAP had low EC50s across cell types, indicating broad toxicity. Mechanistic assays showed that BPAF caused a >10-fold increase in radical oxygen species (ROS) in Caco-2 cells (1,270.4 ± 187.4 RFU/cell at 10 μM; $p<0.01$), while HepaRG cells had a milder response (161.6 ± 14.1 RFU/cell). BPAF, BPAP, and BPE disrupted mitochondrial membrane potential in Caco-2 and HepaRG cells at concentrations as low as 0.01 μM. BPP uniquely elevated mitochondrial calcium in HMC3 cells at 10 μM (320.3 ± 52.7 RFU/cell), suggesting apoptotic signaling. Caco-2 cells were the most sensitive overall, while HepaRG cells were more resistant. Again, Bisphenol exposure elicited distinct, compound- and cell-type-dependent activation of the PERK-eIF2α-ATF4 pathway. HepaRG cells showed the most robust and dose-responsive ER stress activation, accompanied by consistent increases in cytochrome C and strong correlations between ER stress markers and apoptosis-related responses. Caco-2 cells exhibited moderate ER stress activation with limited propagation toward cytochrome C modulation, whereas HMC-3 cells displayed pronounced ER stress signaling without significant cytochrome C association. Regression analyses confirmed cell-specific coupling between ER stress and apoptosis-related responses. Together, these findings provide a mechanistic basis for developing an adverse outcome pathway (AOP) for bisphenol analog toxicity and highlight the importance of mechanistic, multi-cell-based approaches for

bisphenol risk assessment and safer chemical design.

1.02.P-We246 More Than Meets the Shell: BPA Disrupts Multiple Metabolic Pathways in the Freshwater Snail Planorbella pilsbryi

David McNabney[1], Karyn Robichaud[2], Maria Villella[3], Stacey Robinson[1], Ève Gilroy[1] and Amila De Silva[1] (1)Environment and Climate Change Canada (ECCC), (2)University of Waterloo, (3)Environment and Climate Change Canada

Bisphenol A (BPA) is a widely used industrial chemical in the production of plastics and resins and is a well-established endocrine disruptor in humans and other vertebrates. However, its effects on invertebrates remain comparatively understudied. In this study, we employed non-targeted metabolomics to investigate the biological impacts of chronic BPA exposure in the freshwater pulmonate snail Planorbella pilsbryi. Using liquid chromatography–tandem mass spectrometry (LC–MS/MS), we characterized metabolomic profiles associated with BPA exposure and identified perturbations in key biochemical pathways. BPA exposure resulted in increased lipid abundance and dysregulation of multiple biological pathways, including those related to energy metabolism and digestion. Additionally, a decrease in methylated nucleobases was observed, suggesting potential alterations to DNA and RNA processes that may influence physiological function and gene expression. Overall, this study provides novel insights into the mechanisms underlying BPA toxicity in freshwater snails and demonstrates the utility of metabolomics for assessing sublethal contaminant effects in non-model organisms.

Advancing Molecular Tools and New Approach Methodologies for Next-Generation (Eco)Toxicology and Risk Assessment

1.02.V-01 Metabolism-Aware and Pharmacogenetics-Informed Toxicity Prediction: A Multi-Endpoint Machine Learning Framework With Systematic Platform Benchmarking

Sharhabil Mohamedali[1] (1)Alexandria University

Computational toxicity platforms typically predict safety from parent compound structure alone, ignoring metabolism-dependent toxicity and inter-individual genetic variability in drug metabolism, which together account for a substantial fraction of adverse drug reactions. Whether integrating metabolism-aware screening and pharmacogenetic simulation into multi-endpoint prediction improves safety assessment over existing platforms remains systematically unevaluated.
We developed an open-source platform integrating six toxicity endpoints (cardiotoxicity, hepatotoxicity, mutagenicity, nephrotoxicity, cytotoxicity, and skin sensitization) with rule-based metabolite generation, cytochrome P450 (CYP) phenotype simulation across four metabolizer categories, and a novel Phenotype Sensitivity Index (PSI) quantifying how predicted toxicity varies across genetic subpopulations. We benchmarked it against two leading platforms using 284 multi-endpoint compounds with statistically calibrated decision thresholds, 30 drugs (20 withdrawn for toxicity, 10 controls), and 35 pharmacogenomic drug pairs. The platform achieved strong discrimination across endpoints (area under curve 0.89–0.99). For drugs withdrawn for liver toxicity, it detected 8 of 10 versus 7 of 10 for the comparator. Threshold calibration was critical: optimizing the hepatotoxicity cutoff improved specificity from 6% to 92%. Metabolism-aware

screening generated 15–37 metabolites per compound and flagged reactive intermediates for known bioactivated toxicants, mechanistic information absent from parent-only tools. The PSI metric produced continuous sensitivity estimates that correctly identified drugs with established CYP-dependent metabolism while scoring non-CYP controls at zero.
Metabolism-aware, pharmacogenetics-informed prediction adds clinically relevant dimensions missing from current platforms. The PSI metric bridges structure-based modeling and pharmacogenomics, and the open-source implementation offers a reproducible protocol for next-generation, precision risk assessment integrating artificial intelligence and new approach methodologies.

Disclaimer/Disclosure: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. The authors declare no conflicts of interest

Advancing the Understanding and Test Methods for the Cross Species Extrapolation of Toxicities

1.03.T-01 Organic Ultraviolet Filters Are Inhibitors of Cytochrome P450 Enzyme Activity in Fishes

Vann Boyte[1], Christopher Lowrey-Dufour[2], Lauren Eagon[1] and Jon Doering[2] (1)Louisiana State University Baton Rouge, (2)Louisiana State University

Organic ultraviolet (UV) filters are widely used in personal care products, plastics, textiles, and other industrial applications to protect materials from damage and degradation from UV radiation. These compounds are detected in aquatic environments from recreational water use, wastewater effluent, and landfill leachates. Several organic UV filters are inhibitors of phase I biotransformation enzymes in mammals: cytochrome P450 1A (CYP1A) and cytochrome P450 3A (CYP3A). However, whether organic UV filters share these effects in fishes and if there are differences in sensitivity among species remains unknown. Therefore, the objectives of this study were to determine the inhibitory potency of nine organic UV filters for CYP1A-, CYP2A-, and CYP3A- enzyme activities in fish hepatic microsomes and compare the sensitivity of these enzymes among three diverse fish species. Hepatic microsomes from red drum (Sciaenops ocellatus), American eel (Anguilla rostrata), and spotted gar (Lepisosteus oculatus) were exposed in 96-well plates to serial concentrations of each organic UV filter. Enzyme activities of CYP1A, CYP2A, and CYP3A were measured using ethoxyresorufin-O-deethylase, pentoxyresorufin O-dealkylase, and benzyloxy-4-trifluoromethylcoumarin-O-debenzyloxylase assays, respectively. Alpha-naphthoflavone, clotrimazole, and propiconazole served as reference inhibitors for CYP1A, CYP2A, and CYP3A. The reference inhibitors produced concentration-dependent inhibition across all species, with IC50 values ranging from 150-1070 nM for CYP1A and 52-120 nM for CYP2A. Among the UV filters tested, five inhibited CYP1A activity in all species, while all nine inhibited CYP2A activity. These findings demonstrate several organic UV filters inhibit fish biotransformation enzymes consistent with effects in mammals, and there are differences in inhibitory potency among chemicals and species. The results indicate that organic UV filters can disrupt detoxification pathways in fishes, resulting in synergistic toxicities with other pollutants, such as polycyclic aromatic hydrocarbons or dioxin-like chemicals. This work helps to assess the risk posed to aquatic environments from the widespread use of organic UV filters. These findings support the application of in vitro assays as predictive tools for reducing live-animal testing while improving understanding

of the ecological risks associated with organic UV filters.

1.03.T-02 Advancing Bio-QSARs for Ecotoxicity Prediction Across Chemicals and Species

Jochen Zubrod[1], Nika Galic[2] and Maxime Vaugeois[3] (1)Zubrod Environmental Data Science, (2)Syngenta Crop Protection AG, (3)Syngenta Ltd

Practical, legal, and ethical drivers are accelerating the development of new approach methodologies (NAMs) that can reduce reliance on animal testing in environmental risk assessment. Among these, machine learning-based quantitative structure-activity relationship (QSAR) models are especially promising, but conventional approaches remain limited when extrapolating across diverse taxa. To address this gap, we developed Bio-QSARs for multispecies toxicity prediction by combining chemical descriptors with biological information, enabling simultaneous cross-chemical and cross-species inference.

Here, we present next-generation Bio-QSARs that substantially extend the first-generation framework. Training data were expanded by roughly 20-fold, moving beyond pesticides to a broader chemical universe and from freshwater organisms to aquatic species more generally, while accommodating flexible test durations. Models were trained using Gaussian Process Boosting, which combines tree boosting with mixed-effects modeling to capture both fixed and random effects. In addition to Dynamic Energy Budget parameters, we evaluated alternative sources of biological information, including taxonomic distances and life-history-related descriptors, to improve prediction across taxa.

The resulting models achieved strong predictive performance on independent test sets, with R^2 values up to 0.922 for fish and 0.905 for invertebrates. To support transparency and regulatory confidence, we combined SHapley Additive exPlanations (SHAP) with multicollinearity correction to make model behavior interpretable. We also developed novel applicability domain approaches based on principal component analysis and feature importance, which improved robustness and reduced the frequency of extreme outliers. Incorporating approximately 1,500 curated in-house toxicity records into fish Bio-QSAR training further expanded the feature space, increasing performance (applicability-domain-filtered $R^2 = 0.934$) while reducing extreme outliers to 0.4%.

These enhanced Bio-QSARs demonstrate flexible, explainable, and regulation-ready prediction across chemicals and species, aligning with key OECD principles for model validity and applicability domain definition. Ongoing work is extending the framework to algae and terrestrial plants, with the longer-term goal of building a unified multispecies platform for environmental decision-making.

1.03.T-03 Taxa Sensitivity Differences in U.S. EPA's Ecological Structure Activity Relationships (ECOSAR) Predictive Model and Data Submitted Under the Toxic Substances Control Act

Nicholas Turner[1], Jeffrey Gallagher[1], Jennifer Brennan[1] and Christopher Janson[1] (1)U.S. Environmental Protection Agency (US EPA)

The United States Environmental Protection Agency (U.S. EPA)'s New Chemicals Division (NCD) manages risks to human health and the environment from new chemicals prior to their introduction into U.S. commerce under section 5 of the Toxic Substances Control Act (TSCA). Section 4(h)(2)(A) of TSCA states EPA shall develop: "… strategies to reduce, refine, or replace vertebrate animal testing and provide information of equivalent or better scientific quality and relevance for assessing risks of injury to health or the environment."

These efforts predominantly focus on alternative methods to reduce the use of vertebrate organisms in toxicity tests and include read-across species extrapolation via the use of surrogate test species. In order to provide scientific evidence for the reduction of vertebrates in environmental toxicity testing, U.S. EPA investigated taxa sensitivity differences in the toxicity test data underlying U.S. EPA's Ecological Structure Activity Relationships (ECOSAR) Predictive Model and the toxicity test data submitted under TSCA. This presentation describes EPA's approach to determining the most sensitive surrogate taxa (aquatic vertebrates, aquatic invertebrates, or algae) in acute toxicity tests. The authors will present a graphical comparison and statistical analysis of toxicity test data for industrial chemicals with at least one endpoint for each taxon. This exploratory work may, in the future, support the reduction of vertebrate testing for regulatory decision making by providing evidence of taxa sensitivity differences between specific chemical classes of industrial chemicals.

Disclaimer/Disclosure: Disclaimer: The views expressed in this session are those of the authors and do not necessarily represent the views or policies of the US Environmental Protection Agency.

1.03.T-04 Integration of In Silico Approaches Into the AOP Framework

Justin Dubiel[1], Cameron Collins[2], Andreas Eriksson[1], Vann Boyte[2], Lauren Eagon[2], Fernando Calahorro-Nunez[3], Jonathan Sangiovanni[4], Zhe Xia[5], Gregg Tomy[5], Danielle Philibert[6], Benjamin de Jourdan[6], Jessica Head[4], Odd Karlsen[7], Nicolas Bury[3], Jon Doering[8] and Steve Wiseman[1] (1)University of Lethbridge, (2)Louisiana State University Baton Rouge, (3)University of Southampton, (4)McGill University, (5)University of Manitoba, (6)Huntsman Marine Science Center, (7)University of Bergen, (8)Louisiana State University

Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous environmental chemicals that can induce toxicity by activating the aryl hydrocarbon receptor (AhR). Species differ dramatically in sensitivity to AhR activation by dioxin-like chemicals (DLCs) and PAHs. A predictive model known as a quantitative adverse outcome pathway (qAOP) linking AhR activation by DLCs to early life-stage mortality in birds and fish has been developed to aid in risk assessment, however this model is not applicable to PAHs. This research aims to 1) expand the domain of applicability of the existing model to PAHs and 2) incorporate in silico predictions of acute lethality into the model for PAHs and DLCs. A standardized in vitro reporter gene assay was used to develop species sensitivity distributions for transactivation of the AhR across species birds and fishes. To determine whether in vitro differences in sensitivity to AhR activation correspond with differences in sensitivity to early life-stage mortality, embryos of a subset of fish and avian species were exposed to PAHs by microinjection. Lastly, in silico analysis was performed to determine ligand binding potential energies and investigate the role of receptor subdomains in differences in species sensitivity. Species differences in sensitivity to AhR activation by PAHs exceeded 500-fold and there was a strong and significant relationship between sensitivity to AhR activation (EC50) and sensitivity to early life-stage mortality in fish (LD50; $p = 0.007$, $R2 = 0.86$) and birds ($p = 0.007$, $R2 = 0.91$). Adjustment factors were calculated for PAHs in birds and fish to enable predictions of PAH toxicity to be made using the existing qAOP. Additionally, there was a significant correlation between in silico descriptors and EC50 for activation of the AhR2 by more than 50 ligands representing 6 chemical classes in over 20 species ($p = <0.0001$, $R2 = 0.78$). Computationally derived EC50s were used as an input for the qAOP enabling predictions of early life-stage mortality to be made using purely in silico data with an average accuracy of 4.4-fold, demonstrating the utility of integrating in silico methods into the AOP framework. This model represents an important advancement in predictive toxicology, enabling high-throughput generation of species-specific toxicity data for any AhR agonist in any fish or bird species without the use of animals or cell-based

assays and serves as proof of concept for future research with additional receptors.

1.03.T-05 Application of Cross-Species Quantitative Adverse Outcome Pathways to Risk Assessment: A Case Study on Recruitment Failure in St. Louis River Lake Sturgeon

Nonnie Cook[1], Cameron Collins[1], Lauren Eagon[1], Vann Boyte[1] and Jon Doering[1] (1)Louisiana State University Baton Rouge

Adverse outcome pathways (AOPs) have been pivotal in driving the ongoing shift in the assessment of risk posed by chemicals from an emphasis on whole-animal testing for apical-level toxicities to a greater focus on the measurement of conserved mechanistic endpoints that can lead to apical-level toxicities. The most advanced developments in AOPs, known as quantitative AOPs (qAOPs), describe quantitative response-response relationships linking the molecular initiating event and adverse outcome enabling quantitative prediction of the probability or severity of an adverse outcome for a given magnitude of a molecular initiating event. However, despite the clear applicability of qAOPs to risk assessment, to date, few qAOPs have been developed and even fewer have been used in real-world risk assessment scenarios that inform regulatory decisions. Therefore, the objective of the present study was to use a mature qAOP that describes early life mortality as a function of activation of the aryl hydrocarbon receptor 2 (AHR2) across fishes to determine whether maternal transfer of legacy dioxin-like chemicals (DLCs) are a limiting factor to natural recruitment of lake sturgeon (Acipenser fulvescens) in the St. Louis River (MN, USA) Area of Concern (AOC) towards the goal of guiding removal of this designation. This qAOP can predict full dose–response curves of early life stage mortality for any DLC for any fish species using only the chemical-specific effect concentration from a standardized in vitro AHR transactivation assay transfected with the AHR2 from the target species. Existing data for DLC concentrations in eggs from 7 St. Louis River lake sturgeon and 3 lake sturgeon from a healthy sub-population were used to identify 19 DLC congeners detectable in eggs. An AHR2 cloned from the same lake sturgeon population was used to measure effect concentrations for these congeners using the in vitro AHR transactivation assay. LD50s were predicted using the qAOP. These LD50s were used to develop lake sturgeon specific TEFs for each DLC. TEQs in TCDD-equivalents were calculated for each egg sample. The calculated TEQs were compared to the predicted lake sturgeon mortality curve for TCDD and demonstrate DLCs in all egg samples are below levels expected to cause mortality. This evidence suggests that maternal transfer of legacy DLCs is unlikely to be a contributing factor in the observed recruitment failure and provides support for other drivers unrelated to the AOC designation.

1.03.T-06 Cross-Species Differences in Sensitivity to Disruption of the Thyroid Hormone Receptor Among Fishes

Lauren Eagon[1], Vann Boyte[1], Cameron Collins[1] and Jon Doering[2] (1)Louisiana State University Baton Rouge, (2)Louisiana State University

Metamorphosis is the vital transition from one developmental stage to the next and is largely controlled by the thyroid axis. The thyroid axis can be disrupted by anthropogenic chemicals found in surface waters leading to accelerated, prevented, or delayed metamorphosis. Fishes exhibit a wide range of metamorphic transformations across species, ranging from relatively subtle to dramatic. Current research on disruption of the thyroid axis among fishes focuses almost exclusively on the zebrafish (Danio rerio) which exhibits a subtle metamorphic transformation. Almost nothing is known about differences in sensitivity to disruption among fishes, but the

limited available data suggests that species with more dramatic transformations might be more sensitive. Therefore, as a first step towards characterizing differences in sensitivity to disruption of the thyroid axis among species of fish, this study employed an in vitro thyroid hormone receptor (THR) transactivation assay to determine the sensitivity to chemical agonists and antagonists for 4 fishes that represent a range in metamorphic complexity, namely gulf killifish (Fundulus grandis), spotted gar (Lepisosteus oculatus), southern flounder (Paralichthys lethostigma), and American eel (Anguilla rostrata). Briefly, the THR was cloned from livers of each species and transfected into COS-7 cells. Cells were exposed to serial concentrations 1 chemical agonist and 7 chemical antagonists. Luminescence was read to produce dose-response curves. The prototypical agonist, triiodothyronine (T3), had comparable median effective concentrations (EC50s) across the 4 species. However, EC50s of the 7 antagonists ranged by up to 600-fold among species, with differences largely driven by the sensitivity of the American eel. The American Eel has one of the most dramatic metamorphic transformations in fishes, which could play a role in the increased sensitivity observed. EC50s from this assay were also compared to existing data from in vitro mammalian THR transactivation assays from the US EPA ToxCast database, and all fishes were more sensitive to octisalate and less sensitive to dibutyl phthalate relative to mammals. Ongoing research is focused on linking in vitro species sensitivities to in vivo sensitivities and towards identifying differences in THR amino acid sequences across species to elucidate the molecular mechanism behind the observed differences in sensitivity of the THR.

Advancing the Understanding and Test Methods for the Cross Species Extrapolation of Toxicities

1.03.P-Th018 Data Inclusion and Taxon Weighting Shape Species Sensitivity Distributions and Percentile Estimates

Matthew Etterson[1], Kristina Garber[1] and Tom Purucker[1] (1)U.S. Environmental Protection Agency (US EPA)

Species Sensitivity Distributions (SSDs) are widely used in ecological risk assessments to represent taxonomic differences in contaminant sensitivity. SSDs are used to derive toxicity endpoints intended to protect a specified proportion of exposed species (commonly the 5th percentile, or HC05). Data are first screened for study quality, usually restricted to definitive endpoints (e.g., point estimates of 50% mortality), and then fitted to either taxon-specific geometric means or data distributions. Non-definitive endpoints (NDEs) are “greater than” results when effects exceed the highest treatment level and “less than” results when effects occur below the lowest. Although often excluded at this stage, their removal can discard valuable information on taxonomic sensitivity. We assess how NDE inclusion methods influence SSDs by comparing inclusion versus exclusion of such endpoints, evaluate fitting taxon-level summary statistics versus data distributions, and their combined effects on SSD fits. We apply maximum likelihood algorithms to empirical and simulated datasets to quantify the impacts of these choices on best-fit distributions, parameter estimates, and resulting 5th percentile values. It is widely accepted that censoring non-definitive “less than” values on the lower tail biases HC05 estimates upward (less sensitive), whereas censoring high “greater than” values shift upper-tail percentile estimates downward. Counter-intuitively, we found that including “greater than” NDE at the upper end of the distribution may also result in lower HC05 estimates when the primary influence of the NDE on the fitted SSD is to increase its variance, pushing both tails outward. The effect of NDE also depends on how within-taxon variation in toxicity measurements is handled. When replicate values are tightly clustered, that taxon’s sensitivity is estimated more

precisely than for taxa tested once and could reasonably be given greater weight, so ideally each taxon's weight should reflect the precision with which its sensitivity is known. Fitting SSDs only to summary endpoints ignores available toxicity information and can bias the SSD fit and percentile estimates. Robust data inclusion strategies (such as incorporating non-definitive data) and SSD fitting procedures that fully use available toxicity information (rather than summary statistics) can more fully exploit known uncertainty in the underlying toxicity data, avoiding overly constrained SSD fits.

1.03.P-Th019 Assessing Sensitivity to Dioxin-Like Compounds in Wild Avian Species Using a Genetic Screen

Anwyn Neraasen[1], Félix Fages[1], Ariana Moin Kenary[2], Carina Gjerdrum[3], Letizia Campioni[4], April Hedd[5] and Jessica Head[1] (1)Faculty of Agricultural and Environmental Sciences, McGill University, Ste-Anne-de-Bellevue, (2)Hôpital pour Oiseaux et Animaux Exotiques de Montréal, Montreal, (3)Environment and Climate Change Canada, Canadian Wildlife Service, Dartmouth, (4)Departamento de Biología de la Conservación y Cambio Globa, Estación Biológica de Doñana, Consejo Superior de Investigaciones Científicas (EBD-CSIC), Sevilla, (5)Environment and Climate Change Canada, Biodiversity Research Division, Mount Pearl

In birds, the sequence of the AHR1 gene can be used to predict a species' relative sensitivity to the embryotoxic effects of dioxin-like compounds (DLCs). When combined with non-invasive sampling, AHR1 sequencing provides an alternative to toxicity testing that can be directly applied to wild species, including species at risk. Prior research indicates that the high-sensitivity AHR1 genotype is rare among avian species, and its occurrence does not follow a clear phylogenetic pattern. However, these studies only encompass a small fraction of known avian species. The objective of our research is to complete a survey of AHR1 genotypes across a broader range of avian species, with the goal of identifying potentially vulnerable taxa for further research. We first conducted a retrospective survey of existing AHR1 sequences, including genotypes published in the literature and analysis of avian AHR1 sequences available from GenBank. Next, we performed prospective sequencing of biological samples from two taxa of interest identified by this survey: orders Psittaciformes (parrots and relatives) and Procellariiformes (petrels and relatives). Based on our retrospective survey and prospective sequencing, the AHR1 genotype has been determined for 257 avian species. The low-, intermediate-, and high-sensitivity genotypes occurred in 37%, 54%, and 9% of these species, respectively. Order Psittaciformes had the highest proportion of species with a high-sensitivity genotype, which also occurred in 10 of the 18 Psittaciform species sampled for prospective sequencing. The low-sensitivity genotype was prevalent in most predatory and piscivorous species, except among order Procellariiformes where the intermediate-sensitivity genotype was more common. The intermediate sensitivity genotype was also found in 1 Procellariiform species from our prospective sequencing. AHR1 sequencing for additional Procellariiform samples is currently in progress. Overall, this research provides an updated perspective on the distribution of AHR1 genotypes across a wider diversity of avian species. We also identified species among orders Psittaciformes and Procellariiformes that may be vulnerable to DLC toxicity based on their AHR1 genotype. Further research should be conducted to assess the risks of DLC exposure in these species.

1.03.P-Th020 Extrapolation of PFAS-Nuclear Receptor Interactions Across Species Using SeqAPASS

Ryan Staub[1] and Carlie LaLone[2] (1)Oak Ridge Institute for Science and Education (ORISE), (2)U.S. Environmental Protection Agency (US EPA)

Dependance on in-vivo toxicity data for chemical risk assessment requires substantial resources. One solution is to leverage existing data from model organisms and use New Approach Methodologies (NAMs) to extrapolate across species. The Sequence Alignment to Predict Across Species Susceptibility (SeqAPASS) tool is an in-silico NAM that uses empirical evidence of a chemical-protein interaction in one species to align protein sequences and structures across untested species and generate predictions of chemical susceptibility based on protein conservation.

Because of per- and polyfluoroalkylated substances' (PFAS) environmental prevalence, their interactions with 10 human nuclear receptors (NRs; e.g., estrogen receptor α/β) have been studied. Existing literature uses molecular docking to evaluate thousands of PFAS-NR interactions focusing on PFAS in the CompTox Chemicals Dashboard. Knowing these human NR interactions with PFAS, SeqAPASS can evaluate conservation of NR proteins across species and predict susceptibility across untested species. Ten human NRs were identified from literature (Singam et al., 2024) and submitted to SeqAPASS level 1, comparing similarity of primary amino acid (aa) sequences across species. Ligand binding domains involved in NR-PFAS interactions were analyzed using SeqAPASS Level 2, comparing protein functional regions across species. Individual aas critical to the strongest PFAS-NR binding were identified from existing docking data, and residue conservation was analyzed with SeqAPASS Level 3. Level 1 and 2 results predicted conservation of the NRs for vertebrates. Level 3 identified critical-residue conservation for most vertebrates, though exceptions were prioritized for SeqAPASS Level 4—protein structural prediction and alignment. Generated structural models from species with aa differences were superimposed with crystal structures of a human NR bound to known agonists (rcsb.org) and display conserved structures regardless of individual mutations. These data support the hypothesis that the majority of vertebrates, including 363 marine and 37 threatened/endangered species, are capable of similar binding to PFAS as the human nuclear receptors.

Collectively, these computational results indicate that human PFAS-NR interactions may broadly inform understanding of PFAS-NR interactions across vertebrate species, with few exceptions.

Disclaimer/Disclosure: The views expressed in this article are those of the authors and do not necessarily represent the views or policies of the US Environmental Protection Agency.

Applications of Multi-Omics in Ecotoxicology

1.04.P-Th166 Decoding Tributyltin Toxicity in Zebrafish Embryos at Single-Cell and Spatial Resolution

Liliya Sokalchuk Sokalchuk[1], Albert Menéndez-Pedriza[1], Laia Navarro-Martin[1], Michael Dorrity[2], Joselyne Katherine Caicedo García[3], Joaquim Jaumot[3] and Carole Chedid[4] (1)Institute of Environmental Assessment and Water Research - Spanish National Research Council (IDAEA-CSIC), (2)Structural and Computational

Biology, European Molecular Biology Laboratory, Heidelberg, Germany, (3)Institute of Environmental Assessment and Water Research (IDAEA-CSIC), Barcelona, Spain, (4)Vizgen Inc, 150 Bear Hill Rd, Waltham, MA, 02451, USA

Tributyltin (TBT) is a highly toxic and persistent endocrine-disrupting compound with well-documented adverse effects on aquatic organisms, particularly impacting the development and function of the nervous system and visual structures. However, the effects in specific tissues or cell types are largely unknown, disregarding spatial and cellular heterogeneity, especially relevant when working with small organisms. In the present study, we investigated the effects of TBT in zebrafish embryos' (Danio rerio) single cells and tissues exposed to environmentally relevant concentrations (3nM and 30nM) of TBT for 24h.

Single-cell analysis was performed by NextGEM GEM 3' v3.1 (10X Genomics) in a total of 13700 cells, identifying 28 clusters. Among these, 15 clusters exhibited differential gene expression (DEGs) between control and TBT exposed cells. Notably, neurons and neural progenitors showed 1025 and 436 DEGs, respectively, across treatments. The most affected pathways were associated with the electron transport chain and cell death. Additionally, three eye-related clusters (photoreceptor rods and cones, and retinal cells) showed a marked reduction in cell number at 30 nM, indicating impaired cell survival. In retinal cells, 75 DEGs were identified linked to circadian rhythm and metabolic processes.

MERFISH-based spatial transcriptomics using the MERSCOPE® platform with a 1000-gene panel further supported these findings. A total of 275795 cells and 35 clusters were obtained. This approach enabled improved neuronal resolution and spatial localization of gene expression.
Differential gene expression analysis of glutamatergic and monoaminergic neuronal populations revealed distinct responses to the highest exposure dose. Glutamatergic neurons showed widespread upregulation, whereas monoaminergic neurons exhibited a marked downregulated profile. This shift, indicative of increased excitatory signaling and reduced modulatory control, was supported by phenotypic and behavioral outcomes, including decreased serotonin levels, impaired visual motor response (VMR), and an enhanced startle response.

Altogether, this work highlights the neurotoxic and retinotoxic potential of TBT at environmentally relevant concentrations and underscores the value of integrating single-cell and spatial transcriptomic approaches to uncover cell-type-specific mechanisms of endocrine disruption that conventional toxicological methods may not detect.

1.04.P-Th167 Integrated Multi-Omics Assessment of Neurotoxicity Induced by Cadmium and Ciprofloxacin in European Seabass (Dicentrarchus labrax)

Joao Pedro Raio[1], Janan Gawra[2], Juliette Bedrossiantz[2], Emma Moragrega[3], Irene Romero Alfano[4], Brian Jonathan Young[2], Joselyne Caceido[2], Ariadna Verdaguer[3], Cristian Gómez Canela[5], Demetrio Raldua[4], Joana Pereira[6], Patrícia Pereira[6], Mercedes Blázquez[7] and Laia Navarro-Martin[4] (1)Department of Biology, University of Aveiro, 3810-193 Aveiro, Portugal, (2)Institute of Environmental Assessment and Water Research (IDAEA-CSIC), (3)Institut Químic de Sarrià-Universitat Ramon Llull, (4)Institute of Environmental Assessment and Water Research - Spanish National Research Council (IDAEA-CSIC), (5)Ramon Llull University, (6)University of Aveiro (UA), (7)Institute of Marine Sciences (ICM-CSIC)

Aquatic ecosystems are increasingly challenged by mixtures of contaminants of emerging concern, including

metals and pharmaceuticals. Cadmium (Cd) and the fluoroquinolone antibiotic ciprofloxacin (CIP) frequently co-occur in coastal environments, yet their neurotoxic mechanisms in marine fish remain poorly resolved across biological scales. In line with systems toxicology frameworks, this study integrates biochemical, behavioral, and multi-omics approaches to characterize neurotoxicity in juvenile European seabass (Dicentrarchus labrax) following 21-day dietary exposure.

Fish were exposed to control conditions and environmentally relevant and elevated doses (Cd: 10 and 100 $mg \cdot kg^{-1}$ food; CIP: 1 and 10 $mg \cdot kg^{-1}$ food) under controlled conditions. Neurotoxicity was assessed through antioxidant defenses (SOD, CAT, GST, GPx, GSHt), oxidative damage (lipid peroxidation), acetylcholinesterase (AChE) activity in brain and muscle, neurotransmitters content, and behavior. In parallel, brain samples were collected for epigenomic (DNA methylation, EM-seq) and transcriptomic (RNA-seq) profiling to enable multi-layered interpretation of stress responses.

Both contaminants reduced brain glutathione levels, indicating increased susceptibility to oxidative stress. Cd exposure increased SOD activity and slightly elevated lipid peroxidation at the higher dose, whereas CIP showed limited effects on these parameters. AChE activity increased in the brain across all treatments, suggesting disruption of cholinergic signaling, while no changes were observed in muscle AChE. Behavioral analyses revealed reduced locomotor activity, increased freezing events, and enhanced shoal cohesion, consistent with anxiety-like phenotypes and impaired neural function.

Ongoing integration of methylome and transcriptome data aims to link molecular alterations with organismal responses and support the identification of adverse outcome pathways (AOPs). By combining multi-omics with physiological and behavioral endpoints, this study provides a holistic assessment of neurotoxicity and highlights the added value of omics integration for elucidating mechanisms of co-occurring contaminants in ecological risk assessment.

Disclaimer/Disclosure: Acknowledgments: EU project EPIBOOST - DOI: 10.3030/101078991; SP projects PID2021-122929OB-C33 and PID2021-122929OB-C33 financed by MCIN/ AEI/10.13039/501100011033.

1.04.P-Th168 Identification of Novel Urinary Protein and Exosome-Based Biomarkers for Chronic Kidney Disease of Unknown Etiology (CKDu) in Sugarcane Farm Workers

Jie Zhou[1], Jaime Butler-Dawson[2], Kevin Kroll[1], Abdel Alli[1], Yang Yang[3], Lyndsay Krisher[2], Stephen Brindley[2], Lee Newman[2], Nancy Denslow[1] and Chris Vulpe[1] (1)University of Florida, (2)University of Colorado Anschutz Campus, (3)University of Georgia

Chronic kidney disease of unknown etiology (CKDu) is a global health concern, and it sunderlying causes remain unclear. The disease disproportionately affects young, otherwise healthy agricultural workers, and there is a scarcity of biomarkers for early detection. We hypothesized that urinary proteins and exosomes could serve as novel biomarkers for early-stage detection.

We investigated 34 urine samples from sugarcane farm workers in a CKDu-endemic region of Guatemala. 21 kidney injury-associated proteins were quantified using a recently developed Luminex panel. Urinary exosomes were isolated by ultracentrifugation, characterized by NanoSight and TEM, and surface proteins were screened using a flow cytometrybased assay. The lipid composition was determined by mass spectrometry, and miRNAs were identified by next-generation sequencing.

Several protein biomarkers, including MCP-1, clusterin, NGAL, and β2-microglobulin, were significantly elevated in participants with CKDu. Our surface protein assay suggested that urinary exosomes were enriched for the universal markers CD63 and CD81, as well as a family of kidney-driven markers, including CD1c, CD3, and CD24. Importantly, renal damage-associated CD25 and CD45 were highly expressed in individuals with CKDu. We identified 21 potential lipid biomarkers that may distinguish agricultural workers with early-onset CKDu. Remarkably, 14 lipids showed intermediate expression levels in healthy individuals with acute post-work shift injury. Further, we identified 6 miRNAs significantly upregulated in the CKDu group, including miR-30a, miR-204, and miR-10a, which may play critical roles in early kidney disease diagnosis. miR-181a, a renal fibrosis and tubular injury marker, significantly decreased in the CKDu group after a work shift, suggesting its potential role in assessing acute renal damage.

Taken together, this study reveals that urinary protein and exosome-based biomarkers are promising for assessing kidney disease and acute renal damage. Our exploration may ultimately contribute to the early diagnosis of CKDu among farm workers.

Disclaimer/Disclosure: This study is supported by CDC/NIOSH#U54OH011230.

1.04.P-Th169 Integrating Multi-Omics Approaches Reveals the Role of Divalent Metal Transporter 1 in Systemic Metal Homeostasis in Zebrafish

Theanuga Chandrapalan[1] and Raymond Kwong[1] (1)York University

Divalent metal transporter 1 (DMT1) is a major route for iron uptake in vertebrates. However, DMT1 is also capable of transporting multiple other divalent metals, including essential trace elements such as manganese and zinc, as well as potentially toxic metals like cadmium and lead. In aquatic environments, where metal concentrations vary due to natural and anthropogenic sources, DMT1 may play a critical role in regulating metal accumulation and susceptibility to metal stressors. Despite its recognized role in iron acquisition, the systemic importance of DMT1 in multi-metal regulation and coordinated dietary and waterborne uptake in fish remains poorly understood. To investigate the importance of DMT1 in multi-metal homeostasis in fish, we generated a CRISPR-Cas9 dmt1 knockout (dmt1−/−) zebrafish line and applied an integrated approach combining ionomics, transcriptomics, and proteomics. Wildtype and dmt1−/− zebrafish were assessed for tissue metal concentrations, hematological status, and growth, while RNA sequencing of gill and intestinal tissues was used to characterize molecular responses to DMT1 deficiency. Loss of DMT1 altered tissue iron status and disrupted the homeostasis of multiple essential trace metals. These physiological changes were accompanied by extensive transcriptional and proteomic remodeling, including differential expression of genes and proteins involved in metal transport, ion regulation, energy metabolism, oxidative stress responses, and cellular transport processes. Functional enrichment analyses revealed evidence of compensatory mechanisms that may mitigate impaired iron uptake through alternative transport pathways. The integration of multi-omics datasets revealed coordinated changes in RNA, protein, and metals to link changes in tissue metal status with physiological outcomes. These novel findings provide new insight into the role of DMT1 in systemic metal homeostasis and highlight the utilization of multi-omics approaches for elucidating mechanisms underlying responses to metal-related environmental stressors.

1.04.P-Th170 PXR Mediated Responses Following Exposure to Pregnenolone Carbonitrile in Zebrafish

Matthew Jaansalu Jaansalu[1] and Joanna Wilson[1] (1)McMaster University

The pregnane X receptor (PXR) is a ligand activated nuclear receptor responsible for xenobiotic sensing and the regulation of chemical defense pathways. While PXR has been studied thoroughly in humans due to its role in regulating the cytochrome p450 (CYP) enzyme, CYP3A4, which is responsible for metabolism of ~50% of pharmaceuticals, PXR remains understudied in aquatic organisms. The objective of this study is to investigate the transcriptional effects of PXR activation following pregnenolone 16α-carbonitrile (PCN) exposure on chemical defense genes in adult zebrafish (Danio rerio). Despite being a known agonist of PXR in zebrafish, water-based exposures have been used in embryo studies while adult based studies have used injections. An initial qPCR experiment will be conducted to determine the best concentration of PCN to induce PXR while limiting activation of the aryl hydrocarbon receptor (AhR). Using this concentration of PCN, intestine, liver and gill tissues will be sampled from male and female fish after 12, 24, and 48 hours of exposure. Tissues will be subject to a verified bait capture protocol developed in our lab that targets 595 genes involved in zebrafish chemical defense and then sequenced. Analyses will evaluate how gene expression responses vary by tissue type, sex, and exposure length, providing information on spatial and temporal dynamics of PXR mediated regulation. We predict that all sampled tissues will see upregulation of PXR itself with tissues involved in uptake having earlier induction of phase 1 metabolic enzymes including CYP3A65 while liver tissue will see later induction of these genes but also will have induction of more phase 2 conjugating enzymes such as UDP-glucuronosyltransferases (UGTs) and ATP-binding transporters (ABCs). This study will help to understand PXR mediated responses to xenobiotics with applications to the use of zebrafish in drug development.

1.04.P-Th171 Effects of Environmentally Relevant Developmental Exposure to Waterborne Cadmium in Larval Zebrafish (Danio rerio): From Behaviour to Transcriptome

Samira Leila Baldin[1], Francisco Carlos da Silva Junior[1], Sravan Kumar Putnala[1] and Som Niyogi[1] (1)University of Saskatchewan

The present study investigated the developmental and neurobehavioral effects of embryonic exposure to waterborne cadmium (Cd) at environmentally relevant concentrations in zebrafish. Zebrafish embryos were exposed to 0 (control), 1, 5, and 10 µg/L Cd from 2 hours post-fertilization (hpf) to 5 days post-fertilization (dpf). Subsequently, the behavioural effects of Cd in larval zebrafish were assessed by reflexive movement (light and dark response) and thigmotaxis (both at 5 dpf), as well as social preference (at 21 dpf) and object recognition (30 dpf) assays. To explore the cellular and molecular mechanisms underlying Cd toxicity, reactive oxygen species (ROS) production, apoptosis, mitochondrial integrity, and lipid peroxidation were evaluated at 5 dpf by whole-mount DCFDA, acridine orange, and rhodamine 123 staining and ELISA, respectively. Furthermore, transcriptomic changes were evaluated by RNA sequencing in 5 dpf larvae exposed to 1 and 10 µg/L Cd. Embryonic Cd exposure did not have any effect on larval survival and hatching rate but altered reflexive movement and thigmotaxis in a dose-dependent manner. In general, Cd affected anxiety and photo-motor responses in larval zebrafish by inducing hyperactivity. Although Cd did not affect the social preference behaviour, it reduced the novel object exploration ratio at 10 µg/L, indicating cognitive dysfunction. Embryonic Cd exposure increased ROS production, the abundance of apoptotic cells, mitochondrial disruption, and lipid

peroxidation, although these effects were observed predominantly at the highest exposure concentration. RNA-seq analysis revealed dose-dependent transcriptomic changes in the Cd-exposed larvae relative to the control larvae. Transcriptomic profiling revealed downregulation of neuronal, neurodevelopmental, synaptic, neurotransmitter-signalling, metabolic, and immune pathways, accompanied by activation of oxidative stress responses, lipid biosynthesis, iron homeostasis, and circadian regulatory pathways, indicating extensive remodelling of neural and cellular function. Overall, our findings suggest that low-level developmental Cd exposure induces neurobehavioral deficits in zebrafish via oxidative stress and mitochondrial bioenergetic dysfunction, accompanied by a consistent, dose-dependent reprogramming of the larval transcriptome.

Disclaimer/Disclosure: Dean's Scholarship, Saskatchewan Innovation & Opportunity Doctoral Scholarship.

1.04.P-Th173 Microbial Biomarkers of CO_2 Stress in Marine Sediments Across Pressure Gradients

Luis Tejerina[1], Vimbai Machimbirike[1], Oluwatoyin B. Onireti[1] and Javier Santander[1] (1)Memorial University of Newfoundland

Carbon dioxide (CO_2) is a key driver of global climate change, and subseafloor carbon storage has emerged as a potential mitigation strategy to reduce atmospheric CO_2 accumulation. Despite its promise, this approach carries the inherent risk of unintended CO_2 leakage, which could rapidly alter sediment chemistry and expose benthic organisms to elevated CO_2 levels. Microbial communities inhabiting marine sediments are particularly relevant in this context, as they are tightly coupled to geochemical conditions and may serve as early biological sentinels of CO_2 perturbation. Nevertheless, their short-term responses to CO_2 enrichment under different hydrostatic pressures remain poorly understood, largely because recreating deep-sea conditions in controlled laboratory settings is technically challenging. To address this gap, sediment samples from Placentia Bay, NL, were subjected to hyperbaric/hypercapnia experiments designed to simulate both surface pressure and conditions representative of 800 m depth. Triplicate sediments were incubated for 24 h at 6°C under low (1.51 mg/L) and high (10.28 mg/L) CO_2 concentrations, enabling the controlled assessment of microbial responses across two contrasting pressure regimes. Multi-omics approaches were applied to characterize shifts in microbial community composition and functional potential associated with CO_2 exposure. This work provides a detailed view of how sediment-associated microbiomes react to rapid CO_2 acidification and highlights the role of hydrostatic pressure in shaping these responses. By elucidating early microbial indicators of CO_2 stress, our study contributes to a broader understanding of ecosystem vulnerability in the context of subseafloor carbon storage and supports the development of microbially based tools for detecting CO_2 leakage in marine environments.

1.04.P-Th174 Impacts of Perfluorohexanoic Acid on Host Gene Expression and Its Associated Microbiome in Florida Largemouth Bass Following a Dietary Exposure

Jessica Donaldson[1], Shisbeth Tabora Sarmiento[1], Estrella Maldonado[1], John Bowden[1] and Joseph Bisesi[1] (1)University of Florida

Per- and polyfluoroalkyl substances (PFAS) have garnered tremendous concern due to the widespread contamination and environmental persistence as PFAS and their heavy use in commercial products. While the properties of PFAS are useful for various consumer goods, the same properties result in high persistence of

PFAS in the environment as well as an increased risk of exposure and deleterious effects for humans and ecosystems. Historically, research has focused on perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS), but there are more than 9,000 PFAS which can potentially impact human and ecological health in different ways. To address data gaps for less studied PFAS, the use of molecular tools is essential to identify novel toxicity pathways that help to reduce additional animal testing for this large chemical class. Additionally, the use of these tools across both model and non-model species will help determine whether testing data can be extrapolated across species. In our current study, we exposed a non-model species of recreational and economic importance in the state of Florida (largemouth bass) to an emerging PFAS, perfluorohexanoic acid (PFHxA), via the diet. Fish were exposed over 28 days to an environmentally-relevant dietary doses (10 and 100 ng/g) as well as a higher dose (1000 ng/g). At the end of the exposure, fish were euthanized, weighed, and measured to examine effects on growth, hepotosomatic index, and gonadosomatic index. Liver tissues were processed for mRNA and gene expression via qPCR analysis focusing on immune and lipid pathways that were identified through a previous transcriptomics analysis. Gut microbiome was assessed to determine the impact of PFHxA on the microbial community as PFAS has been shown to impact the gut-brain axis in fish. Total cholesterol, free fatty acids, and lipid peroxidation were assessed in the plasma on day 28 to determine specific lipid effects in response to PFHxA exposure. The exposure is underway, but we anticipate that these results will drive the development of new approach methodologies and assays that can help to screen the 1000s of PFAS with unknown toxicity profiles, which are needed to make accurate estimates of the potential risk these chemicals pose. This study will be the first to examine sub-chronic dietary exposures to PFHxA and the resulting impacts on non-model species.

1.04.P-Th175 Comparative Developmental Metabolomics of Model and Non-Model Amphibian Species To Improve Cross-Species Extrapolation

Jill Awkerman[1], W. Matthew Henderson[2], Donna Glinski[2], Crystal Lilavois[2], Robin Van Meter[3], Simone Jarvis[2], Candice Lavelle[2] and Tom Purucker[2] (1)U.S. Environmental Protection Agency (US EPA), (2)U.S. Environmental Protection Agency (US EPA), (3)U.S. Fish and Wildlife Service

Amphibians are among the most threatened vertebrates and are not directly tested in most standard ecotoxicological risk assessments. Verifying conserved response mechanisms in amphibians is fundamental to the implementation of cross-species predictive risk assessment approaches. While agrochemical exposure is one of the prevalent stressors of this group, amphibian populations also are limited by habitat modifications and disease. Many stressors impact the same biochemical pathways (e.g., oxidative stress, immunological response, endocrine disruption). We identified common physiological responses between model and non-model native species as a means of evaluating cumulative impacts in situ. To test the assumptions of a common chemical defense response in amphibians, we compared the metabolomes of a model species (Xenopus laevis) and a common North American species (Lithobates sylvaticus), analyzing whole body and hepatic metabolites throughout larval development. We observed common trends in endocrine function as well as differences associated with biological functions that could indicate greater vulnerability during the larval stage. This new approach methodology provides a foundation for continued extrapolation of stressor effects from model species and offers the potential to identify more sensitive species without investment in extensive animal testing.

Disclaimer/Disclosure: The views expressed in this abstract are those of the author(s) and do not necessarily

represent the views or the policies of the U.S. Environmental Protection Agency.

Building Confidence in Omics Technologies

1.05.T-01 Establishing Bioinformatic Best Practices for Transcriptomic Points of Departure (tPODs): Insights From a HESI Workshop

Jason O'Brien[1] (1)Environment and Climate Change Canada

Transcriptomic points of departure (tPODs) represent the lowest dose at which there is a detectable concerted change in gene expression in response to chemical exposure. tPODs from short-term studies have been shown to be highly protective of potential long-term adverse effects, making them a valuable tool in risk assessment. The Health and Environmental Sciences Institute (HESI) convened a workshop with experts from academia, industry, and government to develop a consensus bioinformatics approach for deriving tPODs. Participants were organized into four subgroups focused on Study Design, Quality Control and Upstream Processes, Pre-Filtering, and Gene Set versus Distribution Approaches for tPOD derivation. Through case studies using diverse public and industry datasets, each subgroup evaluated existing practices, identified research gaps, and developed recommendations and bioinformatic workflows for deriving robust, health-protective tPODs. Subgroup analyses revealed several key insights: Study design decisions, particularly around dose selection and replication, substantially influenced tPOD stability and reproducibility. Differences in upstream processing steps, such as RNA sequencing depth, alignment, and normalization methods, generally yielded comparable tPODs but highlighted the importance of outlier identification—especially when gene expression signals were weak. Effective signal detection required carefully calibrated pre-filtering parameters to balance minimizing false positives and capturing meaningful biological responses. For tPOD derivation, both distribution-based and gene set-based approaches produced protective and quantitatively comparable values, though the reliability of gene set methods for mechanistic inference remains an area of ongoing consideration. Workshop outcomes include planned harmonization of bioinformatic workflows, publication of case studies, and a best practices commentary aimed at supporting near-term regulatory adoption and ongoing refinement of tPODs as practical tools in chemical risk assessment.

1.05.T-02 A Practical Approach for Estimating the Variability of Transcriptomic Points of Departure: A Case Study in Four Aquatic Model Organisms Exposed to Diverse Chemical Classes

Phillip Ankley[1], Jenna Cavallin[2], Kendra Bush[2], Justin Stewart[3], Kevin Flynn[2] and Daniel Villeneuve[2] (1)ORISE U.S. EPA, (2)U.S. Environmental Protection Agency (US EPA), (3)Oak Ridge Institute for Science and Education (ORISE)

Derivation of a transcriptomic point-of-departure for cell lines, animal tissues, or whole-body homogenates of aquatic organisms, exposed to chemicals has been proposed as a new approach methodology (NAM) for broad scope identification of bioactive potency. However, the field has not yet settled on consensus approaches for deriving a tPOD from a distribution of gene- or pathway-specific benchmark concentrations (BMCs) nor estimating the variability of the resulting tPOD. The objectives of this project were to compare five different tPOD derivation methods applied to a diverse chemical dataset (total chemicals = 147) for the four model

aquatic organisms (Raphidocelis subcapitata, Pimephales promelas, Daphnia magna, and Chironomus dilutus) and develop and evaluate variability estimate of the calculated tPOD using a two-level nested bootstrapped methodology including gene sampling with replacement and BMC uncertainty estimation. The median bootstrapped and observed tPOD values were compared across chemicals with varying BMC distributions to understand how they can influence the tPOD derivation method. The "best" tPOD derivation method, defined as that with the greatest composite score accounting for uncertainty and precision was identified. The five tPOD derivation methods included 10th percentile BMC, 25th ranked BMC, first mode, lowest consistent response dose (LCRD), and accumulation plot maximum curvature (PODAccum). LCRD was the most sensitive tPOD method across all chemicals and species, followed by PODAccum, 10th percentile BMC, 25th ranked BMC, and first mode. The 25th ranked BMC and 10th percentile BMC methods had the most similar relationship between the bootstrapped median tPOD and observed tPOD, with lowest overall median bootstrapped log10 standard deviation. The composite scoring approach indicated that that 25th ranked BMC and 10th percentile BMC were optimal approaches for reduced tPOD uncertainty. Using a less complex percentile approach for tPOD derivation had greater stability overall across diverse BMC distributions. This research expanded the ability to identify uncertainty of different tPOD derivation methods and allowed the ability to calculate 95% confidence intervals to increase the acceptance of transcriptomics-based NAMs.

Disclaimer/Disclosure: The contents of this abstract neither constitute, nor necessarily reflect, US EPA policy.

1.05.T-03 Optimizing Quality Filters Used To Derive Transcriptomic Points of Departure for Aquatic Organisms

Daniel Villeneuve[1], Ryan Staub[2], Mackenzie Nash[2], Kendra Bush[2], Jenna Cavallin[1] and Kevin Flynn[1] (1)U.S. Environmental Protection Agency (US EPA), (2)Oak Ridge Institute for Science and Education (ORISE)

The US Environmental Protection Agency is developing ecological high throughput transcriptomics (eco-HTTr) assays as a new approach method (NAM) for application in ecological chemical safety assessment. The main output of these assays is derivation of a transcriptomics-based point of departure (tPOD) which conceptually defines a concentration below which a concerted molecular response to the test substance is not observed, and consequently chronic toxicity is unlikely to occur. In practice, derivation of a tPOD involves application of a range of analysis parameters and quality filters that need to balance between minimizing false positive detection of concentration-responsive genes without inflating false negative rates. Thus, both understanding the potential influence of various parameters and quality filters on the derived tPOD and the optimal, or at least scientifically defensible, settings to employ in a standardized tPOD derivation workflow is important for establishing eco-HTTr as a NAM suitable for regulatory application. The present study employed transcriptomic data sets from larval fathead minnows (Pimephales promelas) exposed to 27 different test substances to evaluate the effect of ten different analysis parameters and quality filters on the chemical-specific tPODs. Regression model averaging, selection of higher benchmark response levels, and imposing higher fold-change cut-off significantly shifted the tPOD toward higher concentrations, depending on the BMC distribution. In contrast, settings for Hill model flagging, minimum best fit p-value, allowed size of the BMC confidence interval, and the number of permutations employed for a Williams trend test pre-filter had minor to negligible effect on the tPOD. Minimum R2 setting for the best fit regression model had a moderate effect, but only for certain data sets. Fold-change cut-offs greater than two, benchmark response levels greater than 1.5 standard deviations, and minimum R2 >0.75 inflated inter-assay variability in the tPOD estimates. Results inform definition of recommended filter

settings to apply in deriving tPODs from eco-HTTr assays.

Disclaimer/Disclosure: The contents of this abstract neither constitute, nor necessarily reflect US EPA policy.

1.05.T-04 Transcriptomic Responses of Rainbow Trout (Oncorhynchus mykiss) to S-Metolachlor in the Context of Environmentally Relevant Mixtures

Aylish Marshall[1], Hugo Marchand[1], Ryan Chui[1], Emily Boulanger[1], Niladri Basu[1], Stéphane Bayen[1] and Jessica Head[1] (1)McGill University

S-metolachlor is one of the most widely used herbicides for controlling broadleaf and grass weeds in North America. As a result, it is ubiquitously found in North American waterways, alongside a multitude of other chemical contaminants. Establishing toxicity thresholds for S-metolachlor, and other contaminants, in the context of environmentally relevant complex mixtures is a major challenge for the field of ecotoxicology. Here, we use a bioassay in early life stage rainbow trout (Oncorhynchus mykiss) to establish transcriptomic points of departure (tPODs) for S-metolachlor in environmentally relevant water samples. Newly hatched rainbow trout (<24 hours post-hatch) were exposed to increasing concentrations of S-metolachlor spiked in a laboratory water control, and three different samples of river water with varying levels of background agricultural contamination, including atrazine and metolachlor at concentrations ranging from low ng/L to low µg/L. After 24 hours of exposure, mortality was recorded and surviving larvae were pooled and preserved whole for RNA Sequencing. LC50 values were statistically equivalent among the four water types, ranging from 35.8 – 73.7 mg/L of S-metolachor (nominal). RNA sequencing data were analyzed using ExpressAnalyst to identify differentially expressed genes (DEGs) and derive tPODs. tPODmode values, defined as the mode of the first peak of benchmark dose values across DEGs, were consistently lower than their associated LC50s, ranging from 3.8 – 9.7 mg/L (nominal). Pathway analysis revealed dysregulation of genes related to ferroptosis, mineral absorption, glutathione metabolism, biosynthesis of amino acids, cysteine and methionine metabolism, and metabolism of xenobiotics by cytochrome P450. These results align with previously published findings for acetochlor, another chloroacetanilide herbicide, supporting a potential common mechanism of action: these compounds may disrupt metabolism in aquatic vertebrates by interfering with antioxidant pathways, leading to oxidative damage, lipid peroxidation, and cell death through ferroptosis. Our results suggest that tPODs can capture sublethal impacts of chemical exposure, identify biological pathways of toxicity, and remain stable across varying environmental conditions. Given that all observed thresholds were several orders of magnitude higher than concentrations detected in environmental waters, S-metolachlor is unlikely to pose a risk to rainbow trout under current conditions.

1.05.T-05 Omics Enhancement of OECD249 for Chronic Fish Toxicity: Transcriptomic Points of Departure (tPOD) for 71 Chemicals in Rainbow Trout RTgill-W1 Cells

Krittika Mittal[1], Ke Xu[1], Sophie Emberley-Korkmaz[1], Geoff Hodges[2], Bruno Campos[2], Claudia Rivetti[2] and Niladri Basu[1] (1)McGill University, (2)Unilever

The Organization for Economic Cooperation and Development (OECD) standardized the rainbow trout gill cell (RTgill-W1) cytotoxicity test guideline 249 as an alternative to fish acute toxicity. There is increasing interest in enhancing this test to also yield information on chronic toxicity. This may be achieved using transcriptomic points of departure (tPODs), which have been shown to correlate well with apical thresholds from chronic tests

as seen in recent work with pesticides in the RTgill-W1 cells. To further evaluate this hypothesis, our objectives were to A) assess cytotoxicity of two panels of chemicals (42 and 29 chemicals) in RTgill-W1 cells, and derive EC20 values where possible, B) Conduct transcriptomics on treated RTgill-W1 cells using derived EC20s as the highest tested concentration (or 100 µM in the absence of cytotoxicity) and calculate tPODs using the TPDseq workflow, and C) compare the nominal and in vitro-mass balance model (IV-MBM) predicted tPODs against comparator in vitro and chronic data, respectively, where available. In the first panel, the initial cytotoxicity screen resulted in EC20s for 18 of the 42 chemicals ranging from 1.75 to 97.42 µM. Analysis of the RNAseq data yielded tPODs for 41 of the 42 chemicals with the tPODmode ranging from 0.008 to 31.18 µM, and tPOD10th ranging from 0.0001 to 12.92 µM. Comparing nominal tPODs to external in vitro tPODs (from zebrafish ZEM2S and ZFL cell lines) showed differences in sensitivity across cell lines with the RTgill tPODs being more sensitive in a majority of the cases, particularly food-related chemicals including caffeine and saccharin. Comparing IV-MBM predicted tPODs to available chronic apical and non-apical data showed that the tPODs were protective of the median chronic data in most cases. Analysis of the second panel of 29 chemicals is ongoing. This study demonstrates that OECD249 can be enhanced with transcriptomic measures to study a library of chemicals with diverse physicochemical properties and varying toxicity profiles, and that the calculated tPODs are comparable to fish chronic toxicity values.

1.05.T-06 Transcriptomic Points-of-Departure Benchmarked to Chronic Endpoints for PFOA and PFOS-K in Fishes

Ryan Chui[1], Hugo Marchand[1], Elli Hung[1], Emily Boulanger[1], Julie Robitaille[2], Kristin Mueller[3] and Jessica Head[1] (1)McGill University, (2)Ministry of the Environment, the Fight against Climate Change, Wildlife and Parks (MELCCFP), (3)Ministry of Environment Quebec

Chronic hazard data are helpful to understand the effects of persistent chemicals in freshwater systems, but are often unavailable due to lengthy exposure times. Shortening exposure times requires other endpoints than chronic endpoints, such as transcriptomics. Transcriptomic methodologies have shown promise in producing hazard data that may serve as surrogates for chronic hazard data. Here, we combine early-life stage fish assays and transcriptomic methodologies to test two forever chemicals, perfluorooctanoic acid (PFOA) and potassium perfluorooctanesulfonate (PFOS-K) in three fish species. Species included in our study were zebrafish (Danio rerio) which has abundant chronic hazard data, rainbow trout (Oncorhynchus mykiss) which has some hazard data, and chinook salmon (Oncorhynchus tshawytscha) which have rarely been tested. Eleutheroembryos (<24 hours post-hatch) for each species were exposed for 24-hours across 12 concentrations of each chemical. Mortality was noted and used to derive 24-hour acute LC50 values, and surviving eleutheroembryos were pooled (n = 3 per concentration) for RNA extraction and sequencing. Established bioinformatics pipelines will be used to perform differential expression analysis to identify dose-responsive genes. These genes will undergo transcriptomic dose-response analysis to obtain benchmark doses, which will be used to derive the concentration that results in significant molecular change, hereafter known as transcriptomic points-of-departure (tPODs). Acute LC50 (in nominal concentrations of mg/L) for PFOS-K are as follows, chinook salmon = 88, rainbow trout = 114 and zebrafish = 118, while concentrations for PFOA are, chinook salmon = 548, rainbow trout = 592 and zebrafish = 576. Preliminary results suggest that acute LC50 values were approximately 5.5-fold lower for PFOS-K than PFOA, with no difference between species. These LC50 values are consistent with the literature, indicating that PFOS-K is more toxic to fish than PFOA. The next steps for this study are to 1) determine if obtained tPODs follow the same trend as the LC50s, and 2) benchmark our obtained tPOD values

with available chronic data. If tPODs align closely with chronic data, it could strengthen confidence in using tPODs as a surrogate for chronic data.

Building Confidence in Omics Technologies

1.05.P-Th178 Hepatic Transcriptional Remodeling in Mice Following Chronic Exposure To Organically Bound Tritium: A Sex-Specific Response

Md Gulam Musawwir Khan[1], Lauren Sidhu[1], Hui Qun Chen[1] and Marilyne Stuart[2] (1)Canadian Nuclear Laboratories, Chalk River, Ontario, (2)Canadian Nuclear Laboratories (CNL)

Organically bound tritium (OBT) emits low energy beta radiation and could pose a health risk. For internalized tritium, this impact is enhanced because OBT is retained longer in biological tissues than tritiated water (HTO). The long-term physiological and molecular impacts of chronic low-dose OBT exposure remain poorly defined, particularly in a sex-specific context. In this study, both male and female mice (CBA/CaJ) were continuously exposed to either tritiated amino acids (AMN) or tritiated fatty acids (FAT) (internal dose rate 4×10^{-4} mGy/day) through multiple generations. The second-generation mice were evaluated for systemic, hematological, biochemical, and hepatic transcriptomic alterations.
Female mice exposed to AMN exhibited a significant increase in body and liver weight, whereas male mice showed a marked reduction in liver mass following FAT exposure. Hematologic analysis revealed elevated white blood cells and lymphocyte counts in AMN-treated males, while female mean platelet volume (MPV) decreased under both AMN and FAT. Blood chemistry results further demonstrated a female-specific alteration in hepatic (ALP) and renal indices (CRE), whereas males displayed FAT-related decreases in serum calcium (Ca^{2+}) and sodium (Na^{+}), pointing toward sex-dependent electrolyte modulation. RNA sequencing of AMN-exposed livers revealed distinct clustering of treated vs. control samples, and broader transcriptional modulation in females than males. Gene Set Enrichment Analysis (GSEA) showed that female hepatic transcriptomes were enriched for anabolic and metabolic pathways consistent with liver growth and proliferation. Conversely, male livers displayed stronger negative enrichment of stress-associated pathways, DNA repair, and cell cycle checkpoint and proliferation signaling, thus contributing to reduced liver weight in the FAT group.
Collectively, these findings demonstrate that chronic low-dose OBT exposure induces strongly sex-dependent physiological and transcriptional adaptations. These results highlight sex as a critical modifier of biological responses to internal tritium exposure and have implications for radiobiological risk assessment and health impact modeling.

Disclaimer/Disclosure: This Work was Supported by Atomic Energy of Canada Limited's Federal Nuclear Science & Technology Work Plan.

1.05.P-Th179 Genome-Wide CRISPR Screens Identify C18orf32 as a Novel Modulator of PFOA-Induced Cytotoxicity and Lipid Dysregulation

Chris Vulpe[1] and Mani Tagmount[1] (1)University of Florida

Perfluorooctanoic acid (PFOA) remains a public health concern due to its persistence in the environment, despite global production bans. Epidemiological, animal, and in vitro studies have consistently linked PFOA

exposure to hepatotoxicity characterized by lipid dysregulation; however, the molecular mechanisms underlying these adverse effects in humans remain poorly understood. To address this gap, we employed an integrated functional toxicogenomics framework combining CRISPR screening (for gene target identification), target validation, and assessment of target-derived cellular and molecular phenotypes. From genome-wide CRISPR screens in HepG2/C3A human liver cells, we identified 319 candidate genes (140 sensitive and 179 resistant) that modulate PFOA-induced cytotoxicity. Among these, C18orf32—encoding a lipid droplet (LD)-associated protein and the top resistant candidate—was selected for further mechanistic investigation based on its potential functional involvement in lipid metabolism. Targeted knockout (KO) of C18orf32 increased cellular resistance to PFOA and markedly reduced LD and triacylglycerol (TAG) accumulation in PFOA-exposed cells, suggesting a functional role for C18orf32p in PFOA-mediated lipid dysregulation. Transcriptomic analysis revealed that C18orf32 KO induced broad gene expression changes both in the absence and presence of PFOA exposure, indicating fundamental cellular status remodeling. Notably, multiple lipid metabolism-related pathways, including cholesterol metabolism, PPAR signaling, fatty acid metabolism, and peroxisome β-oxidation—known mediators of PFOA-induced hepatotoxicity—were significantly decreased in C18orf32 KO cells regardless of exposure condition, suggesting widespread lipid metabolic remodeling. Lipidomics further demonstrated a marked reduction in TAG levels in C18orf32 KO cells, accompanied by alterations in several additional lipid species, confirming C18orf32 KO-mediate cellular and molecular phenotypic outcomes. Collectively, our findings support a functional role for C18orf32p in mediating PFOA-induced lipid dysregulation and hepatotoxicity in human liver cells.

1.05.P-Th180 In Vitro Transcriptomic Points of Departure (tPODs) for 42 Chemicals in the Human Caco-2 Cell Line

Ke Xu[1], Krittika Mittal[2], Geoff Hodges[3], Claudia Rivetti[3] and Niladri Basu[1] (1)McGill University, (2)Mcgill University, (3)Unilever

Omics strategies such as transcriptomics are gaining scientific and regulatory interest because they can capture early molecular perturbations and be used to derive transcriptomic points of departure (tPODs) as potential alternatives to apical points of departure (aPODs) derived from animal studies. In this study, we provide a case study of the TPD-seq workflow, which integrates cell-based exposures, a commercially available RNA-seq library preparation kit, and a cloud-based bioinformatics platform (ExpressAnalyst.ca). Specifically, human intestinal epithelial Caco-2 cells were exposed to 42 chemicals with diverse physicochemical properties across a semi-log concentration range between 0 and 100 μM. Initial toxicity screening classified chemicals based on cytotoxic responses, followed by concentration-response testing to derive EC20 values used to define the highest exposure concentrations for transcriptomic analysis. Bioinformatics analysis of the RNA-seq data produced tPODs for all 42 chemicals, with tPODmode values ranging from 0.36 to 29 μM. Comparison of nominal tPODs with available in vitro data from the CompTox database for HepaRG, U2OS, and MCF7 cells suggested cell line-specific differences in sensitivity. Notably, Caco-2 cells showed lower tPODs for several food-related chemicals, including saccharin and niacinamide. Nominal tPODs were subsequently converted to predicted experimental concentrations using IV-MBM EQP v2.1 mass balance model and further translated into transcriptomic administered equivalent doses (t-AEDs) using the httk R package. When compared with available chronic in vivo toxicity values, t-AED10th showed stronger concordance than AEDmode, with Spearman's ρ values of 0.66 and 0.53, respectively. Overall, most t-AEDs were protective relative to median chronic PODs. These findings demonstrate that the TPD-seq workflow can efficiently generate tPODs and

pathway-level information for a broad range of chemicals with varying degrees of cytotoxicity, supporting its potential application as an animal-free and informative, high-throughput chemical screening and risk assessment tool.

1.05.P-Th181 Balancing Concentration Responsive Gene Detection and False Discovery When Deriving Transcriptomic Points of Departure With Aquatic Organisms

Mackenzie Nash[1], Kendra Bush[2], Jenna Cavallin[2], Ryan Staub[1], Kevin Flynn[2] and Daniel Villeneuve[2] (1)Oak Ridge Institute for Science and Education (ORISE), (2)U.S. Environmental Protection Agency (US EPA)

The US Environmental Protection Agency is developing ecological high throughput transcriptomics (eco-HTTr) assays as a new approach method (NAM) for application in ecological chemical safety assessment. From these assays, a transcriptomic point of departure (tPOD), defined as a concentration below which a concerted molecular response to a chemical is not observed, can be used as a predicted no effect concentration. Selection of parameters used in the benchmark concentration (BMC) modeling process is important to minimize false discovery while still identifying sufficient concentration responsive genes (CRGs) to support robust tPOD derivation. To assess the influence of parameters and filters on the number of CRGs identified, inter-assay tPOD variability, and assay false discovery rates (FDRs), the present study employed positive and negative control data from 11-12 independent assays each completed in four aquatic species: larval fathead minnows (Pimephales promelas), crustaceans (Daphnia magna), insect larvae (Chironomous dilutus), and green microalgae (Raphidocelis subcapitata). A tPOD for the same positive control chemical (n=11-12) was calculated while adjusting three parameters/filters: benchmark response level, fold-change cutoff, and best fit regression R2 cutoff. Negative controls from the same data sets were used to assess how the same parameters/filters impacted FDRs. While more stringent fold-change (greater than 2) and R2 (greater than 0.8) cutoffs decreased FDRs across all species, they also led to reduced CRGs from which a tPOD could be calculated, which inflated inter-assay tPOD variability. However, adjusting the benchmark response level had minimal impact on the number of CRGs and tPOD variability. Decreasing fold change and R2 cutoffs inflated the FDR similarly. The most significant reduction in FDR occurred when the minimum R2 cutoff was greater than 0.9 and the benchmark response was greater than two standard deviations. These results inform limits and provide recommendations for filter and parameter settings in tPOD derivation from eco-HTTr assays.

Disclaimer/Disclosure: The contents of this abstract neither constitute, nor necessarily reflect US EPA policy.

1.05.P-Th182 Possible Use of Transcriptomic Points of Departure (tPODs) As Predicted No Effect Concentrations (PNECs): Comparison of tPODs to EPA Office of Pesticide Programs' (OPP) Aquatic Life Benchmarks

Kevin Flynn[1], Camille Baettig[2], Grace Casciano[2], Jenna Cavallin[1], Alex Kasparek[2], Mackenzie Nash[2], Justin Stewart[2] and Daniel Villeneuve[1] (1)U.S. Environmental Protection Agency (US EPA), (2)Oak Ridge Institute for Science and Education (ORISE) research participant at US EPA

The US EPA has been evaluating ecological high throughput transcriptomic (eco-HTTr) assays as New Approach Methods (NAMs) for estimating concentrations of chemicals that would not be expected to cause adverse effects (i.e., PNECs). The concentration at which a chemical elicits a concerted transcriptomic response in short-term assays has been suggested to predict the concentration below which chronic adverse effects would

not be expected. Therefore, the outputs of the eco-HTTr assays, species-specific tPODs, were compared to OPP Aquatic Life Benchmarks derived from harmonized test guidelines and reviewed literature data. Larval Pimephales promelas (a fish), Daphnia magna (a crustacean), Chironomus dilutus (an insect), and Raphidocelis subcapitata (a green algae) were exposed to individual chemicals (5 replicates of 8 concentrations) for 24 hours in 96-well plate format. After exposure, the transcriptomic response was assessed by either targeted sequencing (Biospyder TempO-Seq) or full RNA-seq, and tPODs were derived via concentration response modeling. The four tPODs were then compared to publicly available Aquatic Life Benchmarks to assess their concordance. Currently, 20 chemicals with Benchmarks have also been tested in all four eco-HTTr assays with additional chemicals continually moving through the exposure to data analysis pipeline. The lowest of the four species-specific tPODs was lower than any of the Benchmark values for 15 of the 20 chemicals, and on average the tPOD was within an order of magnitude of the Benchmark. For chemicals in which the tPOD was not protective, the difference was usually less than two orders of magnitude. For example, the lowest Benchmark for carbaryl is 0.5 µg/L (chronic, aquatic vertebrates) as compared to the lowest eco-HTTr tPOD of 10 µg/L. The most extreme difference between Benchmark and tPOD was for methomyl, in which the lowest Benchmark is 0.7 µg/L compared to the lowest tPOD of 134 µg/L. Additional research is required before using these eco-HTTr assays for estimating a PNEC. This includes defining the applicable chemical space, data analysis parameters, and acceptance criteria for both the exposures and the data produced. However, the current results support a possible use of tPODs from eco-HTTr assays to efficiently calculate interim PNECs for screening level assessments and resource prioritization.

Disclaimer/Disclosure: The contents of this abstract neither constitute, nor necessarily reflect US EPA policy.

1.05.P-Th183 3,4 Dichloroaniline (DCA) as a Transcriptomic Positive Control for Fish Toxicity Studies

Krittika Mittal[1], Ke Xu[1], Jessica Head[1] and Niladri Basu[1] (1)McGill University

Current test guidelines (TG) from the Organization for Economic Cooperation and Development (OECD) for fish acute toxicity using zebrafish embryos (TG 236), rainbow trout gill cells (RTgill-W1; TG 249), and the recently proposed rainbow trout alevin (RTA) assay examine embryo survival and cell viability. Increasing scientific and regulatory interest in applying transcriptomic points of departure (tPOD) to chemical screening has driven recent efforts to enhance these fish toxicity tests to include transcriptomic measures. The OECD tests recommend using 3,4 dichloroaniline (DCA) as a positive control for lethality, however, there are no recommendations for a transcriptomic positive control. Our objective was to determine whether we could obtain a consistent and robust molecular response from fish embryos and RTgill-W1 cells exposed to DCA as a potential positive control for transcriptomics. We exposed RTgill-W1 cells and RTA to DCA for 24 h. Exposures were conducted five times in RTgill cells and twice in RTA, and passed appropriate quality control criteria (solvent control viability > 90%, no-cell controls difference for RTgill <20%). We then used the TPDseq workflow, which combines chemical exposures with a commercially available RNAseq library preparation kit and a cloud-based bioinformatics platform (www.expressanalyst.ca). Libraries were sequenced and raw data were analyzed based on recommended guidelines in the US EPA transcriptomics assessment product, including fold change of 1.5, false discovery rate adjusted p-value 0.05, and Williams trend test to identify concentration responsive genes (CRGs). In RTgill, across five exposures, the number of CRGs ranged from 1660 to 4523 and the number of genes with BMDs from 1136 to 2680 of which there were 180 common

gene-BMDs. The mean tPOD10th percentile was 6.98 ± 2.09 mg/L (5.47 mg/L - 11.09 mg/L; CV = 0.30) and tPODmode was 6.13 ± 2.16 mg/L (1.94 mg/L - 7.91 mg/L; CV = 0.35). In RTA exposed to DCA, there were 282 to 720 CRGs, 153 to 537 gene-BMDs and the tPOD10thile and tPODmode were 0.40 to 0.95 mg/L, and 2.37 to 2.47 mg/L, respectively with 69 common gene-BMDs. Both cases yielded consistent numbers with less than a five-fold difference. Further DCA exposures with fish embryos are ongoing, however, these RTgill-W1 and RTA results demonstrate that DCA could be a candidate for a transcriptomic positive control and serve as a quality control metric for transcriptomic-based fish acute toxicity tests.

1.05.P-Th184 Variations of Fatty Acid Profiles in Japanese Medaka Embryos Exposed Oxygenated PAHs

Mirai Uchimura[1], Masatoshi Yamasaki[1], Emiko Kokushi[1] and Seiichi Uno[1] (1)Kagoshima University

Oxygenated polycyclic aromatic hydrocarbons (OPAHs) are emitted from diesel exhaust and industry and can also form through photooxidation and biological metabolism of parent PAHs. Because OPAHs are more water-soluble than PAHs, they may be widely distributed in aquatic environments. However, their developmental toxicity and mechanisms are unclear.
We previously examined several OPAHs in Japanese medaka embryos and observed developmental abnormalities. In particular, benzanthrone (BAN) induced oil droplet discoloration during embryonic development, and all embryos with this symptom died. pyrene-4,5-dione (P45D) induced tail blood flow stagnation followed by tail necrosis, and all embryos with this symptom died within a few days.
Chemical exposure can vary fatty acid composition and lipid metabolism in fish. Fish embryo development and growth depend largely on maternally supplied lipids and fatty acids in the yolk and oil droplets. Thus, changes in fatty acid composition during embryonic development may affect lipid utilization and early development. However, the effects of OPAHs on fatty acid metabolism remain poorly understood.
This study explored the effects of BAN and P45D exposure on fatty acid profiles in Japanese medaka (Oryzias latipes) embryos. Embryos were exposed to DMSO (0.1%) and low (L-group) and high (H-group) concentrations of each OPAH from 0 to 6 dpf. The L-group and H-group were 11 and 71 μg/L for BAN and 11.5 and 180 μg/L for P45D, respectively. Embryos were collected daily, and fatty acids were extracted, derivatized to methyl esters, and analyzed by GC-MS.
BAN and P45D exposure altered fatty acid composition compared with DMSO group, but the patterns differed by compound. The embryos exposed to BAN varied depending on concentration and embryo development. In H-group, omega-3 and omega-6 fatty acids, including EPA, DHA, and arachidonic acid (ARA), increased during early exposure; in L-group, these increased during later exposure. In contrast, P45D exposure showed a unique pattern, with decreased DHA throughout exposure and increased ARA during later exposure. As EPA and DHA are essential for neural development and cell membrane formation, and ARA is a precursor of inflammatory lipid mediators, these specific changes depending on the compounds may reflect the disturbances in fatty acid pathways related to development and inflammatory responses. These results may be associated with different phenotypes in Japanese medaka embryos.

1.05.P-Th185 Toxicotranscriptomics of Lanthanum (La) and Lanthanide Mixtures in Daphnia magna

Yeri Luz Manjarres Hernandez[1], Julie Robitaille[2], Kristin Mueller[2], Damien Biot-Pelletier[2] and Claude Fortin[1]

(1)Institut national de la recherche scientifique, (2)Centre d'expertise en analyse environnementale du Québec

Rare earth elements (REEs) constitute an important component for the green energy industry, among others. However, their use is likely to introduce these elements into the environment, posing risks that may affect ecosystem health and ultimately lead to their deterioration. This project aims to study the effects of lanthanum and mixtures of lanthanides at different concentrations in order to understand the mechanisms of sublethal toxicity in Daphnia magna after 48 hours of controlled exposure. Individuals will be exposed to concentrations of lanthanum and mixtures of lanthanides under controlled laboratory conditions. Transcriptomic and gene expression analyses by RNA sequencing (RNA-seq) will be conducted to identify differentially expressed genes when Daphnia is acutely exposed to different concentrations of lanthanum and to a mixture of lanthanides. The results of this project will allow a better understanding of gene expression changes induced by lanthanum and mixtures of lanthanides, in order to identify the molecular mechanisms associated with hormetic and toxic responses. They may also be linked to the sublethal effects observed during biological assays, thereby contributing to a more comprehensive understanding of their effects on key aquatic organisms such as Daphnia magna. Finally, this project will contribute to the development of new toxicological tests and to the improvement of environmental quality criteria aimed at protecting aquatic and terrestrial ecosystems.

Empirical and Theoretical Methods to Scale Contaminant Effects: Molecular Impacts to Organism Health

1.06.T-01 When Forever Chemicals Don’t Kill Smallmouth Bass but Still Leave a Mark

Jason Magnuson[1], Rebecca Dorman[2], James Candrl[2], Rachel Claunch[2], Landon Keele[3], Célio F. Mariz[4], John Carroll[2], David Soucek[5] and Erin Pulster[2] (1)Geosyntec Consultants, Inc., (2)U.S. Geological Survey (USGS), (3)University of Missouri, (4)Federal University of Pernambuco, (5)EA Engineering, Science, and Technology Inc. PBC

Smallmouth Bass (Micropterus dolomieu; SMB) are economically vital freshwater game fish across North America. Recent disease, endocrine disruption, and episodic mortality events in the northeastern United States have made this species a primary focus of ecotoxicological research. This study evaluated the sublethal health effects of early-life-stage exposure to environmentally relevant concentrations of perfluorooctane sulfonate (PFOS). SMB embryos (24 hours post-fertilization) were exposed for 90 days post-hatch (dph) in a flow-through system using a pulsed intermittent diluter. Treatments included a control, a low concentration (24 ng/L; representing the 95th percentile of U.S. surface waters), and a high concentration (96 ng/L; reflecting levels at Ashumet Pond, a highly contaminated site in Massachusetts). Each treatment consisted of 4 replicate aquaria each stocked with 70 fish (n = 840 total). Traditional toxicological and omics-based endpoints (survival, growth, transcriptomics, histopathology, and eye morphology) were evaluated at 7 and 90 dph. Control fish grew significantly longer than treated fish, although weight, hatch rate, mortality, and eye morphology remained unaffected under these specific PFOS exposure conditions and durations. Additionally, transcriptomic profiling revealed hundreds of differentially expressed genes. Gene ontology, Kyoto Encyclopedia of Genes and Genomes (KEGG), and Ingenuity Pathway Analysis identified enriched canonical, disease, and functional pathways involved in cardiac function, oxidative phosphorylation, and metabolic pathways in 7 and 90 dph SMB, demonstrating that environmentally realistic PFOS exposures can induce molecular-level dysregulation during critical fish developmental stages. These findings provide insight into the molecular mechanisms of

PFOS toxicity in wild fish populations, demonstrating that sublethal impacts occur at environmentally relevant concentrations orders of magnitude below established toxicity thresholds, such as the aquatic life criteria for acute (71,000 ng/L) and chronic (250 ng/L) water column exposures.

Disclaimer/Disclosure: Funding for this project was provided by the U.S. Department of Interior, U.S. Geological Survey Ecosystems Mission Area, through the Environmental Health Program (Contaminant Biology and Toxic Substances Hydrology).

1.06.T-02 Scaling PFAS Effects From Molecular Responses to Reproductive Outcomes Using Transcriptomics and Dynamic Energy Budgets in Fathead Minnows To Assess Risk of Complex Mixtures

Cheryl Murphy[1], Rachel Leads[1], Adrian Deil Manliclic[1], Alexandra Sexton[1], Mehvish Mumtaz[1], Mariska Hamilton[1], A. Daniel Jones[1], Philipp Antczak[2], Louise Stevenson[3], Katherine King[1], Lori Ivan[1], Roger Nisbet[4] and Ferdinand Pfab[5] (1)Michigan State University, (2)University of Cologne, (3)Oak Ridge National Lab, (4)University of California, Santa Barbara, (5)University of California Santa Barbara (UC Santa Barbara)

Per- and polyfluoroalkyl substances (PFAS) are persistent environmental contaminants that can disrupt biological processes across multiple levels of biological organization. Although molecular responses to PFAS exposure are increasingly documented, mechanistic linkages between these responses and ecologically relevant outcomes such as growth and reproduction remain poorly understood. Bridging this gap is critical for advancing predictive ecological risk assessment and developing frameworks that translate molecular perturbations into adverse organism-level effects, particularly for complex mixtures. To address this challenge, we integrated transcriptomic analyses within a standardized fathead minnow (Pimephales promelas) reproduction study. Adult fish were exposed to graded concentrations of PFOS and environmentally relevant PFAS mixtures under controlled laboratory conditions. Traditional apical endpoints, including survival, growth, condition, and reproductive performance, were measured throughout the study. Concurrently, tissues were collected at multiple exposure and depuration time points for transcriptomic analysis to characterize molecular responses and uptake associated with PFAS exposure and reproductive impairment.
Dynamic Energy Budget (DEB) theory provides a quantitative framework for linking molecular perturbations to organism-level effects by describing how organisms acquire and allocate energy among maintenance, growth, and reproduction. We integrate transcriptomic responses with reproductive and physiological endpoints to evaluate whether PFAS-induced molecular changes correspond to shifts in energy allocation that ultimately affect reproductive performance. This approach provides a mechanistic bridge between gene expression patterns, physiological processes, and ecologically relevant outcomes. Future analyses may incorporate molecular docking to identify candidate PFAS-protein interactions and molecular initiating events that underlie observed transcriptomic and energetic responses. Results from this study will contribute to the development of predictive, biologically grounded models that connect molecular responses to adverse outcomes and improve ecological risk assessment of PFAS mixtures and other emerging contaminants.

Disclaimer/Disclosure: Funded by SERDP ER22-3434 to Cheryl Murphy

1.06.T-03 Interpreting Complex PFAS Mixtures for Ecological Risk Assessment in

Daphnia magna Through Integrating Mechanistic Models

Alexandra Sexton[1], Ferdinand Pfab[2], Roger Nisbet[2], Delaney Bellis[3], Cheryl Murphy[1], Philipp Antczak[4], Mehvish Mumtaz[1] and Louise Stevenson[5] (1)Michigan State University, (2)University of California Santa Barbara (UC Santa Barbara), (3)University of Tennessee Knoxville, (4)University of Cologne, (5)Oak Ridge National Laboratory

Aqueous film-forming foams (AFFF), commonly used in firefighting and on military bases, are known to release mixtures of per- and polyfluoroalkyl substances (PFAS) into the surrounding environment. Current standardized toxicity testing methodologies are not well suited to evaluate the ecological effects of complex chemical mixtures. Therefore, the purpose of this study was to develop a novel testing framework that integrates responses across multiple levels of biological organization to improve ecological risk assessment of PFAS mixtures. Modified standardized toxicity tests were conducted to evaluate lethal and sublethal endpoints (mortality, growth, and reproduction) in Daphnia magna exposed to perfluorooctane sulfonic acid (PFOS) and a reconstituted PFAS mixture containing PFOS, PFHxS, PFOA, and PFOSA. Throughout the life-cycle exposure, samples were collected for transcriptomic analyses to link molecular-level responses with individual-level effects. In addition, Dynamic Energy Budget (DEB) modeling was applied to quantify the impacts of PFAS exposure on energy acquisition and allocation, providing a mechanistic framework for interpreting observed effects on growth, survival, and reproduction. A preliminary DEB model fit to the individual-level D. magna data found an initial set of bioenergetic processes impacted by PFOS exposure: increased reserve turnover, increased energy allocation to maturity and reproduction, increased adult mortality, and increased brood pouch mortality. Transcriptomic results from throughout the daphnid life cycle are pending and will be used to inform bioenergetic processes impacted by PFOS and PFAS mixture exposure. The daphnid exposure data also revealed that while PFOS is often considered one of the most toxic PFAS compounds, the reconstituted mixture produced greater adverse effects on survival and reproduction than PFOS alone. By integrating molecular, organismal, and mechanistic modeling approaches, this complex mixture testing framework aims to support prospective and retrospective ecological risk assessments, reduce animal testing, and provide a more effective method for screening chemical mixtures to inform hazard characterization and remediation strategies.

Disclaimer/Disclosure: The present study was sponsored by the Department of Defense's Strategic Environmental Research and Development Program (SERDP) project number ER22-C1-3434. The Oak Ridge National Laboratory is managed by UT-Battelle, for the US Department of Energy under contract DE-AC05-00OR22725.

1.06.T-04 Scaling Molecular Signatures to Tissue Pathology in 6PPD-Quinone Exposed Coho Salmon (Oncorhynchus kisutch)

Justin Greer[1], Ellie Dalsky[1], Carla Conway[1], John Hansen[1] and Jan Lovy[1] (1)U.S. Geological Survey Western Fisheries Research Center

Stormwater pollutants, including 6PPD-quinone and other tire wear constituents, pose significant risks to aquatic life, particularly in high traffic areas with elevated stormwater pollutant loading. Coho salmon (O. kisutch) exposed to 6PPD-quinone can succumb to mortality within hours of runoff exposures in highly polluted areas, yet the mode of action underlying this acute toxicity remains unclear. Understanding how molecular-level perturbations propagate to tissue dysfunction and ultimately whole-organism lethality is critical

for assessing ecosystem-wide impacts and informing the design of safer tire chemical alternatives. The investigate tissue-specific targets of 6PPD-quinone and bridge molecular responses to organism outcomes, coho salmon were exposed to a nominal concentration of 100 ng/L for up to 24 hours. Animals were sampled at multiple time points throughout exposures, including at the onset of loss of equilibrium, a hallmark sign of 6PPD-quinone toxicity, to capture the temporal progression of early molecular signals to overt physiological impairment. Whole-transcriptome RNA sequencing (RNASeq) was performed to characterize molecular perturbations, and results are being integrated with histological assessments to correlated gene expression changes with structural tissue-level damage. Together, these analyses provide a framework for scaling transcriptomic signals to tissue pathology and connecting organ-level dysfunctions to the rapid lethality observed in coho salmon. This multi-scale approach advances mechanistic understanding of 6PPD-quinone toxicity and supports the development of safer alternatives for use in tire manufacturing.

1.06.T-05 Defining Two Quantitative Adverse Outcome Pathways (qAOP) for Estrogen Receptor Agonism Using Benchmark Concentration Response Modeling

Camille Baettig[1], Jenna Cavallin[2], Kathleen Jensen[2], Heather Brown[2], Gerald Ankley[2], Phillip Ankley[1], Chad Blanksma[3], Grace Casciano[1], Kevin Flynn[2], Alex Kasparek[3], Mackenzie Nash[1], Justin Stewart[1] and Daniel Villeneuve[2] (1)ORISE at US EPA, (2)US EPA, (3)SpecPro Professional Services at US EPA

Adverse outcome pathways (AOPs) are mechanistic, evidence-based frameworks linking a toxicant-driven molecular initiating event to adverse outcomes (AOs) at individual or population scales. Because most AOPs are qualitative and lack exposure–response relationships, they cannot alone estimate AO probability or severity. Quantitative AOPs (qAOPs) address this gap by parameterizing response–response relationships among key events, enabling predictions of AO likelihood or magnitude from defined upstream perturbations. This study defined bioactivity thresholds along two ecologically relevant estrogen receptor (ER) AOPs (AOP 445 and AOP 536), both anchored by ER activation and using 17β-estradiol (E2) as the prototypical stressor. Thresholds are expressed as E2 equivalent concentrations to translate in vitro ER potency into ecologically relevant in vivo predictions. Adult fathead minnows (Pimephales promelas) were exposed to E2 for 7 d at eight concentrations (5–1280 ng/L) to identify thresholds for early key events and inform concentration selection for a subsequent 21 d short-term reproduction assay. Benchmark concentration (BMC) modeling derived points of departure, defined as a change exceeding 1.581 relative standard deviation from mean control responses along with the BMC upper (BMCU) and lower (BMCL) limits used as uncertainty intervals, were calculated after the 7-day exposure. Guided by 7 d BMCs, a 21-d reproductive assay tested eight concentrations (3.75–480 ng/L) and evaluated apical, morphological, and histological outcomes. Endpoints aligned to ER AOP key events included hepatic and gonadal gene expression, plasma vitellogenin and steroid hormones, liver and gonad histopathology, and fecundity. After 7 d, BMCs (BMCL-BMCU) for wet weight, gonad weight, gonadosomatic index, and tubercle in males were 305 (173-2343), 191 (129-351), 201 (136-389), and 224 (143-556) ng E2/L, respectively. Plasma androstenedione and testosterone decreased significantly, with BMCs of 41 (14-77) and 13 (6-30) ng E2/L. Vitellogenin (vtg) mRNA transcript abundance was significantly elevated in males, with a BMC of 45 (41-60) ng E2/L. After 21 d, BMCs for wet weight, gonad weight, gonadosomatic index, tubercle size, and vtg mRNA in males were 104 (66-250), 88 (75-99), 90 (80-99), 54 (36-71), and 24 (19-28) ng E2/L, respectively. These E2-EQ thresholds can inform the in vitro potencies required to trigger the associated AOPs in vivo.

Disclaimer/Disclosure: The contents of this presentation neither constitute, nor necessarily reflect, US EPA policy.

1.06.T-06 Identifying the Function of CYP3A65 in Zebrafish (Danio rerio) Toxicity Responses

Maxwell Hendershot[1], Clarice Kwan[1], Hunter Herron[1], Jared Goldstone[2] and Joanna Wilson[1] (1)McMaster University, (2)Woods Hole Oceanographic Institution

Cytochrome P450 (CYP) enzymes mediate the first line of chemical defence in fish, yet the role of the CYP3 subfamily remain poorly understood. The two most abundant hepatic CYP3 isoforms in adult zebrafish (Danio rerio), CYP3A65 and CYP3C1, are constitutively expressed and have increased expression in response to chemical exposure. Using expressed CYPs and NADPH consumption rates as a proxy, we screened 4160 compounds to identify enzyme-specific substrates, identifying 139 candidate substrates for CYP3A65. Many of the top substrates were shared with CYP3C1, however, 29 were selective for CYP3A65 only. I hypothesize that exposure of zebrafish embryos to CYP3A65 substrates will show dose-dependent toxic effects, with toxicity being dependent on compound metabolism. Embryonic wildtype (WT) and CYP3A65 knock out (KO) zebrafish lines were exposed to oxyquinoline hemisulfate (OXYQ) and diphenyl phosphine oxide 1 (DPO-1), compounds that are selectively metabolized by CYP3A65. Survival, hatching, and abnormalities were examined over a 5-day exposure period. Heart rate measurements were examined on day 2 and 3 post fertilization, and a general swimming assay was run at 5 days post fertilization, testing maximum velocity and time spent at the edge of the arena. The CYP3A65 KO line had reduced OXYQ induced mortality at 8 and 16 μM and a reduced incidence and severity of tail abnormalities at 2 μM compared to WT fish. Contrastingly, DPO-1 had a dose dependent impact on heart rate and behaviour, with decreases being observed only in the KO line. This project implies the CYP3A65-mediated metabolism of chemicals may be involved in the toxicity responses of zebrafish. The observed decreased toxicity in the KO fish suggests that OXYQ is bioactivated, helping to elucidate that an OXYQ metabolite is causing the observed toxicity. For DPO-1 the increased toxicity in the KO fish suggest that the parent compound is largely responsible for its toxicity. These findings have shown that the CYP3A65 knockouts have potential to be a useful model for investigating the role of CYPs in the chemical defensome of fish.

Empirical and Theoretical Methods to Scale Contaminant Effects: Molecular Impacts to Organism Health

1.06.P-Th021 Comparative Cardiovascular Developmental Toxicity of DEHP, DEHTP, and EHDPP in Zebrafish Embryos: Potential Links Between Angiogenesis and Endocrine Regulation

DaYeong Lee[1] and Kyunghee Ji[2] (1)Department of Environmental Health, Yongin University, Republic of Korea, (2)Yong In University

Phthalate plasticizers and organophosphate ester flame retardants are widely used in consumer products, yet information regarding the developmental toxicity of alternative additives remains limited. This study compared the cardiovascular developmental toxicity of di(2-ethylhexyl) phthalate (DEHP), di(2-ethylhexyl) terephthalate (DEHTP), and 2-ethylhexyl diphenyl phosphate (EHDPP) in zebrafish embryos and investigated potential

mechanisms underlying their toxicity.
Zebrafish embryos were exposed to DEHP and DEHTP (0.1–1000 μg/L) or EHDPP (0.07–700 μg/L) for 96 h. Developmental and cardiovascular endpoints were evaluated, and genes associated with oxidative stress, apoptosis, cardiac stress, and angiogenesis were analyzed. Behavioral responses and growth hormone/insulin-like growth factor (GH/IGF) axis-related hormones and gene expression were additionally assessed in EHDPP-exposed embryos.
DEHP and DEHTP exposure reduced body length and altered cardiovascular endpoints, including hatching time, pericardial area, and blood flow velocity, accompanied by changes in oxidative stress-, apoptosis-, and cardiac stress-related gene expression. EHDPP exposure increased embryo coagulation and reduced survival, body length, and pericardial area, together with altered expression of angiogenesis- and apoptosis-related genes. Notably, EHDPP at 70 and 700 μg/L significantly decreased GH and IGF-1 levels, disrupted GH/IGF axis-related gene transcription, and reduced behavioral activity.
Overall, DEHP, DEHTP, and EHDPP induced cardiovascular developmental toxicity in zebrafish embryos, although their toxicity profiles differed. The altered angiogenesis-related responses observed following EHDPP exposure, together with changes in GH/IGF signaling and behavior, suggest that endocrine regulation may contribute to cardiovascular developmental toxicity. These findings provide new insights into the mechanisms underlying vascular developmental toxicity induced by emerging plastic additives and organophosphate ester flame retardants.

Disclaimer/Disclosure: This study was supported by the National Research Foundation of Korea (NRF; Project no. RS-2026-25482321).

1.06.P-Th022 Effects of the Brazilian Oil Spill to Early Life Stage Fish Development

Jason Magnuson[1], Célio Mariz Jr[2] and Paulo Carvalho[2] (1)Geosyntec Consultants, Inc., (2)Federal University of Pernambuco

The Brazilian oil spill that occurred between 2019 and 2020 was the largest spill event in Brazil, with over 5300 tons of oil released along the northeast coastline. Polycyclic aromatic hydrocarbons (PAHs) present in the oil were shown to induce toxicity to early life stage fish following exposure, although the mechanisms in which these toxic responses are exhibited are not well understood. To better characterize these effects across different levels of biological organization, zebrafish (Danio rerio) were embryonically exposed to water accommodated fractions (WAFs) of oil containing 33 total PAHs (tPAH) at concentrations (2.25 and 17.94 μg/L tPAH) measured following the spill. Transcriptomic profiling, morphological assessment, histopathology, and behavioral assays were conducted in larvae that were 168 hours post fertilization (hpf). The top enriched gene ontology and Kyoto Encyclopedia of Genes and Genomes (KEGG) pathways were involved in phototransduction, visual perception, gas transport, and drug metabolism in oil-exposed larvae. Larvae had significant reductions in swim bladder diameter and eye area, which corresponded to reduced diameters in the outer plexiform and retinal pigment epithelial layers in oil-exposed larvae. To help anchor these molecular, morphological, and histological endpoints, behavioral assays involved in visually mediated responses and swimming activity will be assessed. This data suggests that the concentrations of PAHs in the oil spilled off the coast of Brazil has the potential to dysregulate proper swim bladder and eye development, which are important for the recruitment and survival of early life stage fish.

1.06.P-Th023 Comparative Developmental and Cardiovascular Toxicity of PFOA and HFPO-DA in Zebrafish Embryos: Evidence for the Involvement of IGF Signaling

Seojin An[1] and Kyunghee Ji[1] (1)Department of Environmental Health, Yongin University

Per- and polyfluoroalkyl substances (PFAS) are persistent environmental contaminants associated with adverse developmental and cardiovascular effects. Hexafluoropropylene oxide dimer acid (HFPO-DA), a replacement for perfluorooctanoic acid (PFOA), has been increasingly detected in aquatic environments, yet its developmental toxicity remains incompletely understood. This study compared the developmental and cardiovascular toxicity of PFOA and HFPO-DA in zebrafish embryos and examined the potential involvement of insulin-like growth factor (IGF) signaling.

Following OECD Test Guideline 236, zebrafish embryos were exposed to PFOA or HFPO-DA (0.012–120 μM) for 96 h. To investigate the role of IGF signaling, embryos were additionally exposed to picropodophyllin (PPP), an IGF1 receptor inhibitor, alone or in combination with PFOA or HFPO-DA. Developmental endpoints, heart rate, and the expression of cardiovascular- and IGF-related genes were evaluated.

Neither PFOA nor HFPO-DA significantly affected coagulation, hatching, or survival following single exposure. However, PFOA significantly reduced body length and heart rate and altered the expression of cardiac developmental, vascular, and IGF-related genes, whereas HFPO-DA induced only limited developmental and molecular responses. Under IGF1R-inhibited conditions, PPP alone and co-exposure with PFOA or HFPO-DA reduced body length and increased igfbp3 expression. Co-exposure with PFOA and PPP further increased malformations and decreased the expression of cardiac developmental genes, while HFPO-DA-related effects became more apparent under IGF1R inhibition, including reduced hatching, survival, and body length.

Overall, PFOA induced more pronounced developmental, cardiovascular, and molecular alterations than HFPO-DA. Increased sensitivity to PFAS exposure under IGF1R-inhibited conditions suggests that IGF signaling may contribute to PFAS-induced cardiovascular developmental toxicity. These findings provide new insights into the mechanisms underlying developmental effects of legacy and replacement PFAS in aquatic organisms.

Disclaimer/Disclosure: This study was supported by the 2026 Environmental Health Professional Training Program funded by the Ministry of Climate, Energy and Environment through the Environmental Health Center at Seokyeong University.

1.06.P-Th024 Comparative Chronic Toxicity and Molecular Docking of Legacy and Emerging PFAS (PFOS, HFBA, and TFA) in Daphnia magna

Alexandra Sexton[1], Delaney Bellis[2], Rana Massoud[1], Federico Sinche Chele[3], Paul Pickhardt[4], Christian Salvador[5], Teresa Mathews[5], Angela Wilson[1] and Louise Stevenson[5] (1)Michigan State University, (2)University of Tennessee Knoxville, (3)Metropolitan Water Reclamation District of Greater Chicago, (4)Lakeland University, (5)Oak Ridge National Laboratory

Per- and polyfluoroalkyl substances (PFAS) are persistent environmental contaminants that have been detected globally in aquatic ecosystems. While the toxicity of legacy long-chain PFAS, such as perfluorooctane sulfonate (PFOS), is well documented, considerably less is known about the chronic toxicity of emerging short-chain and ultra-short-chain alternatives. As the use and environmental occurrence of compounds such as trifluoroacetic acid (TFA) and heptafluorobutyric acid (HFBA) continue to increase, understanding how PFAS chain length

influences biological effects is critical for ecological risk assessment. This study evaluated the chronic toxicity of three PFAS compounds of varying carbon chain lengths and functional groups (TFA (C2), HFBA (C4), and PFOS (C8)) in the freshwater invertebrate Daphnia magna. Organisms were exposed to both environmentally relevant and equimolar concentrations, and effects on survival, growth, and reproduction were quantified. To further investigate potential mechanisms of toxicity, molecular docking simulations were conducted using a putative molecular target in D. magna. At equimolar concentrations, PFOS caused complete mortality, whereas TFA and HFBA produced little to no effect on survival. Growth and reproductive responses varied among compounds, indicating differential sublethal toxicity despite equimolar exposure. In contrast, environmentally relevant concentrations of TFA, HFBA, and PFOS did not significantly affect survival, growth, or reproduction. Molecular docking analyses revealed differences in receptor binding affinity among compounds that were consistent with observed toxicity patterns, providing mechanistic insight into the influence of chain length and functional group on PFAS toxicity. These findings demonstrate that PFAS toxicity in D. magna is strongly influenced by carbon chain length, with long-chain PFOS exhibiting greater toxicity than shorter-chain alternatives. Integrating chronic toxicity testing with new approach methodologies provides a more comprehensive understanding of the mode of action and supports improved ecological risk assessment of both legacy and emerging PFAS contaminants.

1.06.P-Th025 Differential Developmental and Molecular Responses to Propiconazole and Permethrin in Zebrafish Larvae

Minseo Yu[1] and Kyunghee Ji[1] (1)Yongin University

Propiconazole (PCZ), a triazole fungicide, and permethrin (PMT), a pyrethroid insecticide, are biocidal substances widely used in wood preservation products. Environmental release during application may result in aquatic exposure and adverse effects on non-target organisms. This study evaluated developmental and molecular responses to PCZ and PMT in zebrafish embryos.
Following OECD Test Guideline 236, zebrafish embryos were exposed to PCZ (0.001–10 mg/L) or PMT (0.01–100 μg/L) for 96 h. Developmental endpoints were assessed, and expression of genes associated with xenobiotic response, oxidative stress, and neurotoxicity was analyzed using quantitative real-time PCR.
PCZ exposure increased coagulation and delayed hatching at 10 mg/L and significantly reduced larval body length at 0.1–10 mg/L. In contrast, PMT did not significantly affect developmental endpoints. At the molecular level, PCZ increased the expression of xenobiotic response genes (cyp1a, gstp1, and cyp3a65) while decreasing antioxidant defense genes (sod1, cat, and gpx1a). Increased gfap expression further suggested neurostress responses. Although PMT caused no overt developmental toxicity, it significantly decreased sod1, ache, and syn2a expression, indicating disruption of antioxidant defense, cholinergic signaling, and synaptic function. PMT also increased cyp1a and cyp3a65 expression at the highest concentration.
Overall, PCZ induced both developmental and molecular toxicity, whereas PMT primarily elicited sublethal molecular responses without detectable developmental effects. These findings demonstrate that molecular biomarkers can reveal neurotoxic and oxidative stress-related effects not captured by conventional developmental endpoints and highlight their value in the ecological risk assessment of biocidal substances.

Disclaimer/Disclosure: This study was supported by the 2026 Environmental Health Professional Training Program funded by the Ministry of Climate, Energy and Environment through the Environmental Health Center

at Seokyeong University.

1.06.P-Th026 Benchmark Concentration Response Modeling To Define a Quantitative Adverse Outcome Pathway for Androgen Receptor Agonism

Jenna Cavallin[1], Kathleen Jensen[1], Heather Brown[1], Alex Kasparek[2], Gerald Ankley[3], Phillip Ankley[4], Grace Casciano[4], Kevin Flynn[1], Chad Blanksma[2], Mackenzie Nash[4], Justin Stewart[4], Camille Baettig[4] and Daniel Villeneuve[1] (1)U.S. Environmental Protection Agency (US EPA), (2)SpecPro Professional Services at US EPA, (3)University of Minnesota Duluth, (4)Oak Ridge Institute for Science and Education (ORISE)

Adverse outcome pathways (AOPs) provide a scientifically plausible connection between biological activities measured in vitro or at low levels of organization in vivo, and hazards to individuals and/or populations that are of concern for risk assessment and regulation. However, to evaluate the degree of perturbation that is required to trigger key events and elicit the adverse outcome, bioactivity thresholds must be defined. In the present study, bioactivity thresholds were derived for the androgen-receptor (AR) pathway and expressed as 17β-trenbolone equivalents (TRB-EQs). A 7-d exposure to TRB was conducted with adult fathead minnows (Pimephales promelas) to determine bioactivity thresholds for early key events in the AR AOP and define concentration selection for a 21-d short-term reproduction assay focused on apical and morphological/histological outcomes. The 7-d exposure consisted of 8 concentrations ranging from 650 to 12.1 ng/L and a control. Benchmark concentration (BMC) response-modeling was used to determine points of departure, defined as those that exceed one standard deviation from the mean control response. After 7 d of exposure, BMCs were 518, 170, and 194 ng TRB/L for body weight, gonad weight, and gonadosomatic index in female fathead minnows. The threshold for effects on female hepatic vtg mRNA transcript abundance was 33 ng/L, with vtg significantly decreasing with increasing TRB exposure. Based on the BMCs in the 7-d study, a 21-d reproduction study was conducted with 8 concentrations ranging from 150 to 2.5 ng/L and a control. Five replicate, divided tanks housed one pair of male and female fathead minnows with a spawning substrate in each tank section (n=10 pairs/treatment). Endpoints included those related to the key events for the AR AOP (e.g., gene expression, plasma vitellogenin (vtg) and steroids, gonadal histology, and fecundity). The first exposure day in which a BMC could be calculated for fecundity was day 9 (149 ng TRB/L; CI = 96-318 ng/L), but as the exposure continued to 21 d, the BMC for reproductive output (eggs/female/day) decreased to 17 ng TRB/L(CI = 7.1-41.4 ng/L). These TRB-EQ thresholds can be used to help identify in vitro potencies required to trigger the associated AOPs in vivo. This research can be used to help the US EPA's Endocrine Disruptor Screening Program predict probable endocrine hazards based on in vitro potencies and measured screening assays relevant to endocrine molecular initiating events.

Disclaimer/Disclosure: The contents of this presentation neither constitute, nor necessarily reflect, US EPA policy.

1.06.P-Th027 Linking Molecular Responses to Organismal Outcomes Under Complex Contaminant Stress: A Systems Biology Approach for Predictive Ecotoxicology

Louise Stevenson[1], Lea Rahlfes[2], Andre Gergs[3], Ferdinand Pfab[4], Paul Pickhardt[5], Teresa Mathews[1], Natalia Garcia Reyero Vinas[6], Cheryl Murphy[7], Roger Nisbet[4] and Philipp Antczak[2] (1)Oak Ridge National Laboratory, (2)University Hospital Cologne, (3)Bayer Research & Development Services LLC, (4)University of California Santa Barbara (UC Santa Barbara), (5)Lakeland University, (6)No Affiliation, (7)Michigan State University

Ecological risk assessments have traditionally relied on simplified models that expose single species to individual chemicals under controlled laboratory conditions. However, real-world ecosystems are subject to multiple, interacting stressors, particularly from anthropogenic sources, that challenge the predictive power of these conventional approaches. To address this gap, we investigated the effects of coal ash, a complex mixture of heavy metals known to exert toxicological effects, on the freshwater invertebrate Daphnia magna. We quantified both suborganismal (transcriptomic) and individual-level (survival, growth, reproduction) responses to coal ash exposure. We measured the transcriptomic response at multiple time points, enabling us to analyze the suborganismal response of the Daphnia to coal ash exposure throughout their life cycle. We then modeled the response of Daphnia to coal ash using a Dynamic Energy Budget (DEB) model, testing various potentially impacted physiological modes of action (pMoAs). Instead of identifying the pMoA through traditional DEBtox methods which relies on only individual-level data, we correlated these model simulations with significantly differentially expressed genes to identify the best candidate pMoA based on the molecular coal ash signal. For each state variable in the DEB model, we applied machine learning and a variable selection approach (using ARACNE) to identify a set of genes predictive of the state variable. We then sorted the genes associated with this variable selection approach and added them to the ARACNE model using machine learning. The model with the best fit to the DEB state variables (as measured by R2) was selected. This process using transcriptomic data and DEB modeling identified the pMoA of "increased costs of reproduction" as the best description of the impact of coal ash on Daphnia. This study demonstrates a scalable framework for linking molecular perturbations to organismal outcomes, offering a mechanistic basis for assessing the ecological impact of complex chemical mixtures. Our approach advances predictive ecotoxicology by moving beyond chemical-specific assays toward integrative, systems-level models that better reflect environmental realities.

General: Environmental (Human and Ecological) Toxicology and Stress Response

1.07.P-We085 Mercury Selenide Nanoparticle Stability and Mercury Bioaccessibility in Grey Seal Liver: Implications for Human Consumers in the Gulf of St. Lawrence

Sofia Paciello[1], Houssame-Eddine Ahabchane[1], Kevin Wilkinson[1], Maikel Rosabal[2] and Marc Amyot[1] (1)University of Montreal (UdeM), (2)University of Quebec in Montreal (UQAM)

Grey seals (Halichoerus grypus) from the Îles de la Madeleine represent an important food source for Indigenous and local communities in the Gulf of St. Lawrence region (Canada). Their liver accumulates mercury (Hg) at high concentrations, largely as inorganic Hg (>99% of THg in adult seals) bound in mercury selenide (HgSe) nanoparticles — a form traditionally considered biologically inert. However, whether this sequestration holds during gastrointestinal digestion, and whether HgSe nanoparticles can release bioavailable Hg upon consumption, remains unknown. Liver samples from adult and young-of-the-year (YOY) grey seals were characterized for total mercury (THg), methylmercury (MeHg), selenium (Se), and HgSe nanoparticles

before and after a sequential in vitro digestion model (salivary, gastric, and intestinal phases), with supernatant and pellet fractions analyzed by inductively coupled plasma mass spectrometry (ICP-MS) and single-particle time-of-flight ICP-MS respectively.
Bioaccessibility and nanoparticle dynamics differed markedly between age groups, reflecting their contrasting Hg speciation: adults store Hg predominantly as inorganic Hg in HgSe nanoparticles (MeHg/THg ≈ <1%; THg ≈ 105,000 µg/kg ww), while YOY liver contains mostly MeHg (MeHg/THg ≈ 22%; THg ≈ 305 µg/kg ww) with no detectable nanoparticles. The majority of Hg remained in the pellet fraction across all conditions, particularly in adults (>75%). In adults, THg bioaccessibility increased from 1.9% (gastric) to 24.1% (intestinal), with the intestinal bioaccessible fraction consisting predominantly of inorganic Hg. In YOY, MeHg bioaccessibility was substantially higher (40.6% gastric, 9.2% intestinal).
In adults, HgSe nanoparticles were detected before and after digestion, with particle size and concentration varying across phases and fractions (median diameter ~250–330 nm); these results are still under investigation. Notably, while HgSe nanoparticles in adults appear to limit Hg bioaccessibility during digestion, YOY seals, which tend to be preferentially consumed, lack this sequestration mechanism and present substantially higher MeHg bioaccessibility, highlighting an age-dependent exposure risk. Overall, these preliminary findings suggest that Hg bioaccessibility is modulated by age-dependent speciation, with implications for Hg exposure assessment in populations consuming grey seal liver in the Gulf of St. Lawrence region.

1.07.P-We086 Chronic Exposure to Low Levels of Microcystins LR Induced Time-Dependent Serum Metabolomic Signatures in Mice

Dong-Suk Kim[1], Sarah Elizabeth Cook[1], Seohee Ryu[1], Olusheyi L Adediji[1], Zealan Ramirez[1] and Wilson Rumbeiha[1] (1)UC Davis

Harmful algal blooms and their toxins have become major environmental hazards globally. Of the hundreds of toxins produced, microcystins are the most common in freshwater bodies. Human exposure is mainly through drinking water, food webs, and by inhalation. There is a critical knowledge gap on effects of chronic exposure to environmentally relevant concentrations of microcystin (MC) intoxication, including early sensitive diagnostic biomarkers. The goal of this pilot study was to define the histologic, serum clinical chemistry, and metabolomic biomarkers a low dose chronic exposure to MC. To test the hypothesis that chronic exposure to low levels of MC exposure is toxic to the liver and kidney, male C57BL/6j black mice were exposed to 40 ug/kg bw (n=10 per euthanasia time point) microcystin LR (MCLR) via drinking water (Aquapak) for 90 or 180 days [human equivalent dose of 3.2 ug/kg/day]. Controls will receive normal water. Livers and kidneys were evaluated by a board-certified pathologist. Serum was submitted for comprehensive untargeted metabolomics analyses of primary metabolites, biogenic amines and lipids; AST, ALT, BUN and creatinine. There were no changes in traditional serum biomarkers of liver or kidney injury. There was a statistically significant reduction in liver weights of mice exposed to MCLR both on days 90 and 180 ($p < 0.01$ and 0.05 respectively). Renal weight was only significantly lower than control on day 90 ($p < 0.05$). Liver pathology revealed two phases of injury. Phase I (day 90), characterized by hepatocellular necrosis and disassociation, rounding of individual hepatocytes accompanied by hemorrhage. Phase II, characterized by proliferation of bile ducts and oval cells both at portal tracts and scattered in the hepatic parenchyma (day 180). Hemorrhage and necrosis were not evident in Phase II. The kidney was normal. Of the altered metabolites, 42 and 26 respectively were commonly altered on days 90 and 180, respectively. Of these, PC 22:6_22:6, hydroxykynurenine a, KOdiA-PC, PI 18:1_18:2, cinnamic acid, glycosyl- were the top 5 altered metabolites on day 90 in the MCLR group, while PE

P-18:0_22:5, PI 18:1_18:1, PE P-18:0_20:3, PE P-18:0_20:4, LNAPE 16:0_N-18:2 were altered on day 180 in the MCLR group. This study shows that the serum metabolomic profiles for day 90 and day 180 are different. Additional research is needed to identify serum metabolomic signatures consistent with different phases of chronic MC toxicity.

Disclaimer/Disclosure: This research was funded by a UC Davis P30 NIH grant

1.07.P-We088 Medaka and Zebrafish Display Contrasting Responses to Chronic Exposure to Ethinyl Estradiol

Audrey Phan[1], Larissa Kernen[1], Helmut Segner[1], Lisa Baumann[2], Gregory Lemkine[3] and Andrew Tindall[3]
(1)Centre for Fish and Wildlife Health, University of Bern, (2)VU University Amsterdam (VU), (3)Watchfrog S.A.

Medaka and zebrafish have become standard models to study the impacts of endocrine disruptors on fish. Although these two species of fish share many similarities and advantages, there are important differences in terms of sex differentiation which could influence the results of studies relating to the reproductive axes.
To determine the sensitivity of physiological responses of the two species to estrogenic chemicals, we conducted two parallel chronic exposures of both medaka and zebrafish with ethinyl estradiol (EE2). The fish were exposed from fertilisation to 60 days post hatch in an OECD test guideline 234-like exposure. Fish were then reared in clean water for 3-4 months. Endpoints were measured at both the end of the exposure phase and the end of the depuration phase and included physical condition, mortality, gene expression, gonadal sex, reproductive competence and F1 larval survival.
In response to EE2, medaka exhibited an increase in the expression of genes regulated by estrogenic signalling such as vtg and ERα, increased incidence of intersex in genetically male fish, a female biased sex ratio and reduced F1 survival. Expression of vtg and ERα was also increased in zebrafish exposed to EE2. However, after the exposure period, there appeared to be a delay in sex differentiation in zebrafish in response to EE2 and following the depuration period, adult zebrafish exposed to 10 or 30 ng/L EE2 were all phenotypically male. As it was impossible to determine genetic sex with this strain of zebrafish, it is unclear whether this male skewed sex ratio was due to EE2 provoking stress-induced masculinisation of fish that would have developed as female and/or selective mortality of female fish. Histopathological analyses of juvenile zebrafish (30 ng/L) revealed very high amounts of proteinaceous fluid (presumably VTG) in kidney tubuli. Excessive hepatic VTG production can reach levels that exceed renal filtration capacities, leading to death. These effects may have caused female-specific mortality.
Metabolomic studies may also give insights into whether increased mortality and delayed sexual differentiation are linked to increased energy expenditure due to over stimulation of the production of glycoproteins required for oocyte production following exposure to exogenous estrogens. It remains to determine to what degree these effects on sex differentiation are due directly to endocrine signaling and whether they are representative of wild-type ZZ/ZW zebrafish.

Disclaimer/Disclosure: The authors thank Volontariat International d'Enterprise (VIE) for financial aid.

1.07.P-We089 Integrating Human Biomonitoring and Zebrafish Models To Evaluate

Metabolic Effects of BPA and DEHP Exposure in Korea

Kijeong Yun[1] and Kyunghee Ji[1] (1)Yong In University

Bisphenol A (BPA) and bis(2-ethylhexyl) phthalate (DEHP) are ubiquitous endocrine-disrupting chemicals (EDCs) associated with adverse metabolic health outcomes in humans and wildlife. To investigate the metabolic impacts of these contaminants, we integrated population-based biomonitoring data from the Korean National Environmental Health Survey (KoNEHS) with experimental validation using zebrafish (Danio rerio). Urinary concentrations of BPA and DEHP metabolites were evaluated in relation to metabolic health indicators in Korean adults. Epidemiological analyses identified positive associations between BPA exposure and liver enzyme levels, particularly among female participants, suggesting potential disruption of metabolic homeostasis. To explore underlying biological effects, zebrafish were exposed to environmentally relevant concentrations of BPA and DEHP. Exposed fish exhibited metabolic alterations accompanied by histopathological changes in hepatic and renal tissues, indicating impairment of organ function and metabolic regulation. The coincidence between human biomonitoring data and zebrafish responses highlights the utility of integrating epidemiological and experimental approaches for environmental health assessment. Our findings suggest that BPA and DEHP exposure may contribute to metabolic dysfunction through disruptions in liver–kidney physiological interactions. This integrative framework provides mechanistic insight into EDC-associated health effects and supports the use of alternative vertebrate models to strengthen environmental risk assessment and disease prevention strategies. Acknowledgement: This study was supported by the Chemical Safety Management Specialized Graduate School Program funded by the Ministry of Climate, Energy and Environment of the Republic of Korea and administered by the Korea Environment Conservation Agency (KECA) in 2026.

1.07.P-We090 Toxicity of Atmospheric Nanoplastics in Human Lung Epithelia at Environmentally Relevant Concentrations

Eli Wooliever[1], Elizabeth Hale[1], Randy Carney[1] and Sascha Nicklisch[1] (1)University of California Davis (UC Davis)

Lung epithelia represent a critical barrier for toxicology due to their direct exposure to the environment and high degree of vasculature, allowing for local and systemic impairment. Fine particulate matter (PM2.5) can settle out in larger airways and reach the most distal regions of the lung, resulting in a high surface area of potentially impacted epithelium. Following inhalation, PM2.5 can disrupt the functioning of pulmonary epithelia on impact and during prolonged contact, increasing the risk of lung disease and absorption into the bloodstream. Recent studies have detected atmospheric microplastics and nanoplastics (NPs) in air samples and lung tissue, implicating the lung as a substantial pathway for plastic exposure. However, NP mechanisms of toxic action on lung epithelia are still poorly understood, especially at environmentally relevant concentrations. Human bronchial epithelial cells (HBECs) and human alveolar basal adenocarcinoma cells (A549s) were each exposed to pristine 220nm diameter polystyrene (PS), polyvinyl chloride (PVC), and polyethylene terephthalate (PET) NPs at environmentally relevant concentrations (0.1 and 25 ng/mL). In addition to a negative control, a literature-relevant NP concentration (100 μg/mL) was also used for each NP exposure. All exposures lasted 12 hours, with biological and technical replicates, and each experiment was repeated three times. Following exposure, cells were processed for real-time quantitative polymerase chain reaction (RT-qPCR), live/dead staining, enzyme-linked immunosorbent assay (ELISA), or glutathione oxidation state (GSH/GSSG) assays.

Unlike the high reference dose, environmentally relevant concentrations of NPs did not induce a significant stress response in either cell line. This therefore suggests that pristine NPs at environmentally relevant concentrations do not induce a major acute toxic response in human pulmonary epithelial cells. However, chronic effects or transient responses may be captured by extended exposure or time-course studies. The results of our current study underline the importance of environmentally relevant exposure levels when assessing atmospheric NP toxicity.

1.07.P-We091 From Environmental Sampling to Cellular Impacts: Bridging the Knowledge Gap on the Human Health Effects of Microplastics and Nanoplastics in Ambient Air

Luna Rahman[1] and Sabina Halappanavar[2] (1)Biologist, Environmental Health Science and Research Bureau, Health Canada, Ottawa, Ontario, Canada, (2)Research Scientist, Environmental Health Science and Research Bureau, Health Canada, Ottawa, Ontario, Canada; Professor, Department of Biology, University of Ottawa, Ottawa, Ontario, Canada

Human health effects of microplastics and nanoplastics (MP/NPs) remain poorly understood due to limited systematic studies, the lack of environmentally relevant reference materials, and the absence of standardized methods for detecting and isolating MP/NPs from complex environmental matrices. In this study, we addressed these challenges by first characterizing MP/NPs present in ambient air and then developing standardized top-down and bottom-up approaches to generate well-characterized polyethylene terephthalate (PET), polypropylene, and polyethylene particles that closely resemble real-world exposures. Their potential to induce lung injury and toxicity was evaluated using both in vitro and in vivo models.

The study successfully established methods for detecting and isolating MP/NPs in ambient air, as well as for weathering, generating, and characterizing MP/NPs derived from commonly used plastic products. In vitro exposure resulted in MP/NPs type-, dose-, and time-dependent reductions in cell viability, elevated inflammatory protein levels, and increased genotoxicity. MP/NPs were observed within the cytoplasm, mitochondria, and endoplasmic reticulum, with the respirable size ($\leq$2.7 μm) particles exhibiting greater toxicity than the larger ($\geq$ 5 μm) ones. Weathering modified both particle properties and toxicological outcomes.

Notably, irregularly shaped, respirable PET MP/NPs generated from disposable water bottles consistently induced toxicity across in vitro assays. Intratracheal instillation of respirable PET MP/NPs in mice resulted in dose-dependent lung inflammation, lung injury, and particle internalization, primarily within the nucleus and mitochondria of lung cells.

Collectively, these findings provide systematic evidence that real-world MP/NPs have the potential to harm lung cells and tissue. The laboratory methods developed for generating well-characterized MP/NPs from common plastic products offer a valuable platform for future toxicological studies using realistic exposure scenarios. Importantly, these results demonstrate that smaller/respirable MP/NPs can induce cellular and genetic toxicity in experimental models. The presentation will also discuss key methodological challenges and lessons learned, highlighting the complexity of assessing the risks posed by environmental MP/NPs.

1.07.P-We092 Oxidative Stress and Antioxidant Defenses in Humans Associated With Groundwater Arsenic Exposure

Farith González Martínez[1], Boris Johnson-Restrepo[1] and Jessica Mercado Páez[1] (1)University of Cartagena

Inorganic arsenic in groundwater intended for human consumption and poses a significant global public health concern. Its toxicity is mediated through the generation of reactive oxygen species, leading to cell oxidative stress, DNA damage, and carcinogenesis. This study aimed to evaluate the association of chronic inorganic arsenic exposure via groundwater consumption with systemic redox status. 155 participants aged 18 to 81 years were recruited. The total arsenic concentrations were measured in groundwater, as well as in biological matrices; hair and urine, via high-performance liquid chromatography coupled with hydride generation atomic fluorescence spectrometry. The exposure and noncarcinogenic risk were quantified as the lifetime average daily dose (LADD, expressed in µg-As/kg body-weight/day) and hazard quotient, respectively. In addition, redox status in blood plasma was quantified by oxidative damage biomarkers; carbonyl index (CI) and malondialdehyde (MDA) and antioxidant defense markers enzymatic and non-enzymatic; superoxide dismutase (SOD), catalase (CAT) and ferric reducing antioxidant power (FRAP) respectively. Multivariate statistical analyses adjusted for potential confounding variables were performed to examine the associations between LADD and redox status. The groundwater from wells had a median total arsenic concentration of 6.2 µg/L (range: 4.6–10.7 µg/L) and the LADD total had a median of 0.17 µg-As/kg body-weight/day (range 0.03-0.35). The participants were stratified post hoc into two groups: high-exposure daily dose (n=55, LADD >0.30 µg-As/kg/day) and low-exposure daily dose (n=100, LADD ≤0.30 µg-As/kg/day). The total arsenic concentrations in hair and urine were significantly greater in the exposed group ($p<0.001$ for both). The levels of SOD and CAT were also significantly greater in the exposed group ($p<0.001$ for both). Chronic exposure to Inorganic arsenic through contaminated well water is associated with severe alterations in redox homeostasis, which are characterized by increased antioxidant enzyme activity of SOD and CAT.

1.07.P-We093 Exploring a Mechanism Linking Wildfire Smoke Exposure to Neuroendocrine Dysfunction: Leveraging Kisspeptin/NeurokininB/Dynorphin Neurons as a Novel Target

Avery Lessard[1], Zhi Mei Maria Lee[2], Rick McCosh[2] and Luke Montrose[1] (1)Department of Environmental and Radiological Health Sciences, Colorado State University, (2)Department of Biomedical Sciences, Colorado State University

In recent years, a worldwide decline in fertility has been recognized in both men and women. While the underlying causes are not fully understood, environmental exposures such as wildfire smoke exposure have been linked to negative reproductive health outcomes. This project aims to investigate a potential mechanism of toxicity involving the neuroendocrine system. Wildfire smoke is known to cause neurotoxicity, and we hypothesize this leads to neuroendocrine system dysfunction. Kisspeptin/Neurokinin B/Dynorphin (KNDy) neurons which are located in the hypothalamus, play a vital role in the neuroendocrine regulation of reproduction by organizing pulsatile pattern of gonadotropin releasing-hormone (GnRH) and luteinizing hormone (LH) pulses. Adequate GnRH/LH pulses are essential to gonadal steroidogenesis and gametogenesis. Here, we will characterize the response of an immortalized cell line derived from mouse KNDy neurons (KTaR cells) to direct wildfire smoke exposure. Laboratory generated smoldering Douglas fir smoke was administered via liquid suspension onto KTaR cells at variable doses and durations. Immunocytochemistry to quantify

kisspeptin and neurokinin B protein abundance was conducted. We hypothesized that incubation of KTaR cells with Douglas fir-derived particulate matter would decrease neuropeptide expression compared to control cells. Preliminary results show a decrease in Kisspeptin and Neurokinin B after the three-hour exposure and an increase in expression at the six-hour exposure in comparison with the vehicle control. These results were the same across every concentration of particulate matter tested so far. The results from this study could provide insights into which part of the hypothalamic-pituitary gonadal axis may be impacted directly by wildfire smoke particles. Findings may also drive future therapeutic approaches or targets to prevent loss of fertility as a result of wildfire smoke exposure.

1.07.P-We094 Toxdrc: An R Package To Automate Dose-Response Curve Analysis

Jack Salole[1] and Joanna Wilson[2] (1)McMaster University, Nautilus Environmental, (2)McMaster University

As test methods become more sophisticated, the complexity of toxicity test data becomes complex, and can consist of multiple endpoints across many technical and/or biological replicates. Currently, these values are used to determine effect measures (i.e. LC50, IC25) through dose-response modelling. While this process is well understood and can be completed with various programs, consistently applying it over many tests or experimental subsets is a tedious process. The 'toxdrc' package is being developed to address this limitation of current techniques. This package provides a set of modular functions that can ingest raw data, perform quality checks, apply user-specified transformations, fit and select the best fitting dose-response model, and get the specified point estimates across multiple experimental subsets. Importantly, these modular functions are combined into a pipeline function that allows this process to be automate the analysis of large datasets. This package is designed to support both quantal and quantitative endpoints, making it adaptable to diverse test measurements. This package is particularly well-suited for researchers working with large-scale toxicity studies that require efficient, consistent, and transparent data processing across large datasets. Publicly available versions of this package are currently being applied in research contexts to estimate effect measures. Here, we present an overview of the package and a case study using this package to rapidly analyze toxicity data from a dataset with 300 unique experimental subsets in under 5 minutes.

1.07.P-We095 Extracting Ecotox Data With AI: Can ChatGPT Help?

Kiersten McMahon[1] and Phyllis Fuchsman[2] (1)Ramboll Deutschland GmbH, (2)Ramboll Americas Engineering Solutions, Inc.

The rapid expansion of large language models (LLMs) presents a compelling opportunity to streamline data extraction in ecotoxicology. In our previous investigations, our findings suggested that a firewalled implementation of ChatGPT (RamGPT) could accelerate and standardize data-quality assessments of peer-reviewed literature. To further test AI capabilities, we examined whether RamGPT could accurately extract ecotoxicological endpoints from OECD guideline study reports for active pharmaceutical ingredients (APIs). We compiled 40 ecotoxicological studies, targeting a range of chemicals, taxa and endpoints. We developed a data-extraction framework comprising 10 variables covering: test substance, OECD guideline, test species, study duration, and ecotoxicological endpoints. One human extractor independently applied this framework, while a "master prompt" enabled RamGPT to do the same, constraining hallucinations for every claim. After extraction was complete, AI and human results were compared statistically by grading AI results for accuracy. Although the LLM occasionally struggled with correctly extracting study dates and value symbols, data points

rarely diverged between AI and human extraction. In fact, AI was found to extract data with over 98% accuracy. These findings suggest that LLM-assisted data extraction can meaningfully reduce workload in ecotoxicological evidence assessment, especially when paired with targeted human quality assurance and control.

1.07.P-We096 Review of Hardy Kiwi and Raspberry As Soil Pollution Indicators for Terrestrial Risk Assessment

Jin Il Kwak[1] and Hayeon Choi[1] (1)Pukyong National University

Although crop plants are important soil pollution indicators for risk assessment, they insufficiently reflect wild terrestrial environments. Therefore, this study aims to review wild plant species to identify potential soil pollution indicators and to discuss the applicability of the hardy kiwi and raspberry. Given their widespread distribution across South Korea, these two wild plants species are viable candidates for phytotoxicity assessment, as they more accurately represent realistic environmental conditions. This review identified fifteen studies conducting chemical toxicity assessments on the hardy kiwi and six on the raspberry respectively. Among the research concerning the hardy kiwi, the majority of studies focused on boron stress. In the case of raspberry research, limited studies investigated chemical exposure such as herbicides and pesticides. Existing studies on both species have been conducted from the perspective of physiological stress responses or cultivation management. This review reveals a significant lack of research directly evaluating these two species as soil pollution indicators. Therefore, this study suggests that subsequent experimental studies are needed to verify the applicability of the hardy kiwi and raspberry as potential test species for terrestrial risk assessments. This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (RS-2026-25491231) and was also supported by a Research Grant of Pukyong National University (2025).

1.07.P-We097 A Multi-Omics Approach for Investigating Toxicity Variability in the Ciguatera-Producing Dinoflagellate Gambierdiscus polynesiensis

Kehau-Lani Feral[1], Kevin Henry[2], Vaihiti Teaniniuraitemoana[3], Rose-Gaëlle Matohi[2], Jérome Viallon[2], Manoella Sibat[3], Damien Reveillon[3], Mickaël Leclercq[1], Arnaud Droit[1], Guillaume Mitta[3] and Taiana Darius[2] (1)Laval University, (2)Louis Malardé Institute, (3)Ifremer

Ciguatera poisoning is a major seafood-borne illness in tropical and subtropical regions and results from the accumulation of ciguatoxins throughout marine food webs. These toxins are primarily produced by benthic dinoflagellates of the genus Gambierdiscus. Among them, Gambierdiscus polynesiensis is considered one of the most toxic species. However, substantial variability in toxicity and toxin composition has been reported among strains, even under similar environmental conditions, and the biological factors underlying this variability remain poorly understood.

This study explores the hypothesis that toxicity variability in G. polynesiensis is associated with variation across multiple biological layers, including genome, transcriptome metabolome, and associated microbial communities. To investigate this hypothesis, nineteen strains originating from different archipelagos of French Polynesia were cultured under identical conditions and characterized for toxicity and toxin profiles. These phenotypic data are being integrated with phylogenetic, transcriptomic, metabolomic, and microbiome datasets

generated from the same strains.

Our analyses indicate variation in toxicity levels and toxin composition among strains despite identical culture conditions. These observations suggest that intrinsic factors may contribute to contrasting toxicity phenotypes. Further analyses aim to determine whether patterns observed across transcriptomic, metabolomic, and microbial datasets are associated with this variability and whether integrated molecular signatures can be identified.

By combining multiple omics layers with toxicity assessments, this work provides an approach for investigating complex toxicological traits in microalgae and beyond. The study contributes to the expanding application of multi-omics approaches in environmental toxicology and may improve our understanding of the biological factors associated with ciguatera poisoning risk.

Immunotoxicology: From Cells to Organisms

1.08.P-We166 Stormwater Meets Pathogen: Impacts on Coho Salmon (Oncorhynchus kisutch) Survival

Prarthana Shankar[1], Paxton Bachand[2], Ben LaFrentz[3], Caitlin Slabaugh[4], Tony R. Capps[4], Timothy J, Kuzan[4] and John Hansen[1] (1)U.S. Geological Survey (USGS), (2)U.S. Geological Survey, Western Fisheries Research Center, 6505 NE 65th Street, Seattle, WA 98115, USA, (3)Aquatic Animal Health Research Unit, U.S. Department of Agriculture - Agricultural Research Service, Auburn, AL 36832, USA, (4)Washington Department of Fish & Wildlife, Olympia, WA 98501, USA

Washington State operates the largest system of salmon hatcheries in the world, releasing an average of 26 million coho salmon (Oncorhynchus kisutch) each year to support declining wild populations facing numerous environmental stressors. After release, juvenile coho encounter at least two major challenges: infectious disease and exposure to anthropogenic contaminants. Flavobacterium columnare (F. col), the causative agent of columnaris disease, is an emerging pathogen of concern in the Puget Sound due to its widespread presence in natal streams and its potential for increased virulence under degraded environmental conditions such as elevated temperatures. Concurrently, coho salmon are acutely sensitive to 6PPDQ-quinone (6PPDQ), a highly toxic transformation product of the tire rubber antioxidant 6PPD found in urban stormwater runoff. Coho may be exposed to 6PPDQ during early stream residency or during fall migration, yet the sublethal effects of this chemical, particularly its influence on disease susceptibility, remain poorly understood. This study examines how 6PPDQ exposure affects coho salmon susceptibility to F. col. Our first objective is to develop a reproducible laboratory challenge model for F. col infection in juvenile coho. An F. col isolate collected from a symptomatic juvenile coho at the Lake Aberdeen Fish Hatchery, WA in 2025 was cultured on TYES media and transferred to the USGS Western Fisheries Research Center. Coho (<2 g) will be immersed for one hour at 16 °C in bacterial doses up to 1.5×10^7 cfu/mL, followed by 21 days of daily monitoring under flow-through conditions. Mortalities will be examined for characteristic columnaris lesions, and F. col will be reisolated from gill and head kidney tissues in a subset of sampled fish. Challenge conditions will be refined based on cumulative mortality outcomes and repeated to establish a reliable waterborne infection model. Once established, this model will be used to assess two contaminant–pathogen interaction scenarios: (1) whether prior 6PPDQ exposure (up to 96 hours) alters susceptibility to F. col, and (2) whether acute 6PPDQ exposure (24 hours) affects cumulative percent mortality in already infected fish. Given the scale of hatchery releases in

Washington and the increasing prevalence of urban contaminants, understanding how 6PPDQ influences infectious disease outcomes is essential for informing management strategies and supporting the resilience of coho salmon populations.

1.08.P-We167 4 Nonylphenol Alters Innate Immune Responses in Bigg's Killer Whale Skin Cells Challenged With Microbial PAMPs

John Hansen[1], Paxton Bachand[1], Andrea Roth-Monzón[1], Justin Greer[1] and Mark Jankowski[2] (1)U.S. Geological Survey (USGS), (2)U.S. Environmental Protection Agency (US EPA)

Cetacean skin health serves as an important indicator of overall physiological condition and can provide early warning of environmental stressors. Recent photo surveillance studies have documented an increase in skin lesions among endangered Southern Resident Killer Whales (Orcinus orca; SRKW) inhabiting the Salish Sea, a population already vulnerable to stressors including reduced prey availability, vessel noise, microbial infection, and chronic exposure to persistent organic pollutants (POPs). Orca skin functions as a major immunological barrier and is metabolically active, integrating lipid metabolism, cellular signaling, and immune processes that interact with pollutant responses. Among POPs, 4 nonylphenol (4 NP)—a synthetic surfactant used in detergents and personal care products and frequently detected in stormwater—is an endocrine disrupting compound capable of penetrating the cetacean skin barrier and potentially altering physiological function. In this study, we used genome wide transcriptome profiling to evaluate how 4 NP influences immune signaling and metabolic pathways in killer whale dermal fibroblasts challenged with LPS and poly(I:C) to mimic microbial infection. Lineage verification by RNA seq confirmed that the Bigg's killer whale cell lines express dermal fibroblast markers (vimentin, collagen 1A, PDGFRA, N cadherin) and lack keratinocyte/epithelial markers (cytokeratin 5 and 14, E cadherin). AlamarBlue assays were then used to determine the concentration producing reductions in metabolic activity, yielding an EC_{50} of 59 μM. Exposure (EC10) to 4 NP resulted in 273 differentially expressed genes ($FC \geq 2$; $pAdj \leq 0.05$) at 24 hr., while both LPS and poly(I:C) induced antiviral and pro inflammatory pathways such as IFNB1, IFNG, IL8, IL1B, and TNFA. Pathway analyses of co exposures (4 NP/LPS and 4 NP/poly(I:C)) across multiple time points (2, 6, 24, and 48 hrs.) revealed perturbations in antimicrobial signaling, including altered pathogen recognition receptor activity, inflammatory and antiviral networks, and metabolic pathways such as lipid metabolism. Finally, we will present efforts to develop ELISAs for cetacean pro-inflammatory effectors to support and validate transcriptomic findings. Collectively, these results clarify how contaminant exposure and infection interact to influence orca skin physiology, providing mechanistic insight that can inform management and conservation strategies for at risk killer whale populations.

1.08.P-We168 Environmental Exposure to Food Additive Nanomaterials Induces Differential Responses in Healthy and Ulcerative Colitis Patient Derived Organoids

Estee Ngew[1], Saji George[1], Ke Xu[1], Niladri Basu[1], Jarvis Stobbs[2] and Talat Bessissow[1] (1)McGill University, (2)Canadian Light Source

Environmental exposure to food additive nanomaterials (fNM), including food-grade titanium dioxide (fg-TiO2), titanium dioxide nanoparticles (nfg-TiO2), and food-grade silicon dioxide (fg-SiO2), is increasingly recognized as a potential contributor to intestinal stress. This is particularly relevant in ulcerative colitis (UC) patients, where repeated cycles of inflammation and remission can compromise epithelial barrier integrity.

However, the effects of fNM on the sensitized epithelium remain poorly understood. We used complementary in vitro and ex vivo human model: patient-derived organoids and paired biopsies from UCr patients and non-IBD controls to assess differential responses to fNMs. Organoids were exposed to fg-TiO2, nfg-TiO2, or fg-SiO2 (0–100 μg/mL, 48 h) and evaluated for cytotoxicity, oxidative stress, inflammatory cytokine secretion, gene expression, and transcriptomic responses by RNA sequencing. Biopsies were exposed ex vivo to 100 μg/mL fNM and imaged by synchrotron radiation micro-computed tomography (SR-μCT) to assess tissue architecture in three dimensions, while ICP-MS quantified titanium retention. UCr organoids showed greater susceptibility to fNM-induced stress than non-IBD organoids. All tested fNMs produced stronger dose-dependent toxicity in UCr organoids, accompanied by increased intracellular and mitochondrial ROS generation and elevated pro-inflammatory cytokine secretion. UCr organoids also displayed greater disruption of epithelial barrier-associated genes and cytoskeletal organization. RNA sequencing revealed enrichment of pathways related to inflammatory bowel disease, tight junction regulation, and cancer-associated pathways in fg-TiO2 and fg-SiO2-exposed UCr organoids, whereas these responses were less pronounced in non-IBD controls. Ex vivo, SR-μCT demonstrated mucus barrier disruption and altered tissue structures in UCr tissue following fNM exposure. ICP-MS confirmed increased titanium retention in UCr biopsies (n=5). Using a human-relevant, animal-free testing platform integrating patient-derived organoids, biopsy explants, transcriptomics, and synchrotron imaging, we demonstrate that the UCr epithelium retains a persistent vulnerability to fNM exposure. These findings provide mechanistic evidence supporting population-stratified risk assessment of inorganic food additives and establish patient-derived organoids as a powerful model for environmental nanotoxicology in vulnerable human populations.

Disclaimer/Disclosure: S.G. acknowledges support by CRC/George/X-coded/248475, Canada Foundation for Innovation (CFI), and NSERC discovery grant for this work. T.B. acknowledges funding from Abbvie Canada and Takeda Canada. E.N. acknowledges scholarships from McGill Graduate Excellence Award.

1.08.P-We169 Ramifications of Virus Infection Recovery in Honey Bees

Vincent Prayugo[1], Adam Dolezal[1], Samantha Dubbs[1] and Zainub Ahmad[1] (1)University of Illinois at Urbana-Champaign

Honey bees frequently encounter viral infections in the environment, yet the long term ramifications of surviving these infections remain poorly understood. Here, we tested whether recovery from Israeli acute paralysis virus (IAPV) reduces lifespan and alters worker resilience to subsequent stressors, namely pesticides and pathogens. To do this, we exposed day-old worker bees to Israeli acute paralysis virus (IAPV) and maintained them for 3 days to ensure survivors have completely cleared IAPV infection. We then quantified (1) lifespan under nutritionally rich and poor conditions to simulate resource-limited stress, (2) xenobiotic tolerance using LD50 measurements against lambda-cyhalothrin and P450 activity quantification, (3) IAPV reinfection on survivor bees at a “high” and “low” concentrations to evaluate immunity. Our results indicate that IAPV-recovered bees experienced long-term costs as demonstrated by the significantly shorter lifespan under any nutritional conditions and lower pesticide tolerance. On the other hand, survivor bees also had an improved resilience against a subsequent IAPV infection – indicating immune priming. These results reveal that acute viral infections impose lasting deficits that reduce resilience against chemical stressors while simultaneously enhancing viral tolerance. These trade offs highlight the need to incorporate infection history into pollinator risk assessments to predict how subsequent stressors can affect long-term bee health.

1.08.P-We170 Developmental Immunotoxicity of Five Understudied per and Polyfluoroalkyl Substances (PFAS) That Contaminate Drinking Water

Shyla Streeter[1], Drake Phelps[2] and Jamie DeWitt[1] (1)Oregon State University, (2)U.S. Environmental Protection Agency (US EPA)

Per- and polyfluoroalkyl substances (PFAS) are a large class of environmentally persistent contaminants detected in finished drinking water across the United States. Their chemical-physical qualities lead to long half-lives and negative health outcomes in living organisms, including cancer, thyroid disease, immunotoxicity, and developmental toxicity. Despite known immune system and developmental effects, developmental immunotoxicity (DIT) is not well understood. This is critical as DIT can have lifetime consequences. Perfluoro-2-methoxyacetic acid (PFMOAA), Nafion byproduct 2 (NBP2), perfluoropentane sulfonic acid (PFPeS), sodium-perfluoro-3,5,7,9,11-pentaoxa dodecanoic acid (PFO5DoA-Na), and hexafluoropropylene oxide dimer acid (GenX) were assessed in this study. C57BL/6 female mice were mated with C3H males and were gavaged with vehicle control or one of three PFAS concentrations from gestational day (GD) 1 through GD17. At birth, postnatal day 1 (PND1), litters were culled to 6 pups and weaned at PND21. Subsets of pups were euthanized on PND 21 and PND 28 for organ and sera collection. At PND51, remaining pups were immunized with sheep red blood cells (SRBCs) to elicit T cell-dependent antibody responses (TDAR). Five days later at peak IgM antibody production, pups were euthanized. Blood, spleen, thymus, kidney, brain, heart, and liver were collected for organ weights, immunophenotyping, TDAR, and peroxisome proliferation analyses. NBP2, PFO5oA-Na, and GenX exposure statistically ($p < 0.05$) increased liver mass, a common adverse outcome from PFAS exposure (27%, 41%, and 24% respectively). NBP2, PFPeS, and PFO5DoA-Na exposure statistically increased peroxisome proliferation (30%, 75%, and 105% respectively). PFO5DoA-Na exposed pups had statistically decreased spleen weights in the second highest dose at PND 56 (15%). Exposure to PFPeS led to a statistical decrease in liver weight (13%) and exposure to PFMOAA statistically increased the TDAR (16%). No other statistical changes in the TDAR were observed.
Changes in PFAS-relevant endpoints confirm that gestational exposure to NBP2, PFPeS, PFO5DoA-NA, and GenX lead to detectable outcomes. Suppression of the TDAR is a common finding in adult rodent models exposed to PFAS. Lack of this finding in a DIT model, but presence of other PFAS-relevant health effects, suggests either different toxicological mechanisms or shifts in dose-response patterns in the developing immune system compared to adults.

Disclaimer/Disclosure: The USEPA had no role in study design, data collection, or manuscript preparation. Jamie DeWitt serves as a plaintiff's expert witness in PFAS litigation. Drake Phelps received a consulting fee for PFAS toxicological expertise and literature support. All other authors declare no competing interests.

1.08.P-We171 Examining Potential Immunotoxicity of Three Understudied PFAS Found in North Carolina Waters (PFO4DA, Nafion Byproduct 1, and PFO2HxA)

Macon Carroll[1], Tracey Woodlief[2], Aya Ahmed[2] and Jamie DeWitt[1] (1)Oregon State University, (2)East Carolina University

Per- and polyfluoroalkyl substances (PFAS) are a large class of synthetic compounds, with many members understudied. Perfluorooctanoic acid and perfluorooctane sulfonic acid, two well-studied PFAS, have been classified as presumed immune hazards; this raises questions about the immunotoxic potential of understudied

PFAS. Three such PFAS found in North Carolina waters are perfluoro-3,5,7,9-butaaoxadecanoic acid (PFO4DA; CAS 1035377-21-9), perfluoro-3,6,-dioxa-4-methyl-7-octensulfonic acid (Nafion byproduct 1 (NBP1); CAS 29311-67-9), and 2-[difluoro(trifluoromethoxy)methoxy]-2,2-difluoroacetic acid (PFO2HxA; CAS 39492-88-1). Three immunotoxicity studies were conducted, one for each compound. Adult male and female C57BL/6 mice (6-8 weeks old) were exposed by gavage once/day for 30 days at 0, 0.05, 0.5, or 5 mg/kg for each PFAS. Mice were injected with sheep red blood cells five days prior to study terminus to induce T-cell dependent antibody responses (TDAR). At terminus, spleens were collected and immunophenotyping of various markers for B cell maturation and differentiation was conducted via flow cytometry; the TDAR was evaluated via ELISA. PFO4DA had statistical differences in plasmablast numbers in females between controls and the 0.5 mg/kg dose and between controls and the 5 mg/kg dose. We observed statistical differences in naïve, follicular, and memory B cell numbers in NBP1-exposed males between controls and the 0.05 mg/kg dose. PFO2HxA had statistical differences in marginal B cell numbers and memory B cell numbers in females between controls and all other doses. The TDAR did not vary statistically by dose for PFO4DA or NBP1. We observed statistical differences between controls and the 0.05 mg/kg dose in females exposed to PFO2HxA. These PFAS, chosen for their lack of toxicological data and relevance to the people of North Carolina, produced shifts in major B cell subsets. While these shifts did not appear to directly align with dose-responsive changes in the TDAR, they still indicate effects on B cell subsets. Shifts in B cell subsets can signal not only potential changes in responses to vaccinations, but other disease indicators such as autoimmune disease and cancers. These compounds are only a few of the PFAS found in North Carolina waters and other water sources, globally. Further investigation is needed to explore the potential clinical implications of these findings and whether exposure to PFAS mixtures alters the severity of the results.

1.08.P-We172 Ozone-Induced Iron Dysregulation as a Mechanism of Asthma Exacerbation

Samuel J. Cochran[1], Evangeline Schott[1], M. Leslie Fulcher[2], Phillip Clapp[2], Rachael E. Rayner[3], Estelle Cormet-Boyaka[3], Robert M. Tighe[4] and Kymberly M. Gowdy[1] (1)Division of Pulmonary, Critical Care, and Sleep Medicine, The Ohio State University, Columbus, OH, (2)Airway BioCore, Marsico Lung Institute, The University of North Carolina, Chapel Hill, NC, (3)Veterinary Biosciences, College of Veterinary Medicine, The Ohio State University, Columbus, OH, (4)Department of Medicine, Duke University, Durham, NC

Ground-level ozone (O3) is a gaseous environmental hazard formed from primary air pollutants reacting with heat and sunlight. Increasing global temperatures are predicted to increase ground-level concentrations of this highly reactive gas, which causes damage to sites of respiration in plants and animals. In humans, O3 exposure increases morbidity of cardiopulmonary diseases, including asthma. However, mechanisms of O3-induced asthma exacerbation are understudied. It is known that O3 inhalation induces pulmonary iron accumulation, which is independently associated with asthma severity. Iron can be released from iron-storing proteins (ferritin) through autophagy (ferritinophagy), which is also associated with respiratory disease. We hypothesized that ferritinophagy drives excess iron and mediates O3-induced asthma exacerbation. To test this, we obtained primary human bronchial epithelial cells (HBEC) from asthmatics and non-asthmatics to assess baseline intracellular iron. We also collected bronchoalveolar lavage fluid (BALF) from asthmatic and non-asthmatic humans following exposure to filtered air (FA) or 0.200 ppm O3. Finally, we generated a mouse model of O3-induced exacerbation of allergic airway inflammation (AAI), whereby C57BL/6J mice (12 weeks old) were sensitized to and challenged with house dust mite (HDM) or vehicle control (PBS) and then exposed

to FA or 1 ppm O3 for 3 hours. Our preliminary data indicates that baseline iron levels are higher in HBECs isolated from individuals with asthma compared to non-asthma controls. Following an acute O3 exposure, BALF iron levels increased in humans with asthma but not non-asthma controls. Additionally, AAI mice exposed to O3 had a significant increase in airspace iron compared to both FA and non-AAI controls. This coincided with increased pulmonary inflammation and production of the type 2 cytokine, IL-13. Finally, O3 increased mouse lung tissue expression of nuclear coactivator receptor 4 (Ncoa4) and ferritin (Fth1), which respectively initiates ferritinophagy and can be upregulated in response. Combined, these data suggest that the environmental toxicant, O3, can induce NCOA4-mediated ferritinophagy, leading to excess airspace iron, and driving asthma exacerbation. Iron overload may also serve as a mediator of O3-induced toxicity in other biological models. Future investigations will assess the efficacy of NCOA4 inhibitors in reducing O3-induced asthma exacerbation and iron dysregulation overall.

1.08.P-We173 Utilizing Transgenic Zebrafish To Screen per- and Polyfluoroalkyl Substances (PFAS) for Potential Immunotoxicity

Emma Hepworth[1] and Jeff Yoder[1] (1)North Carolina State University

Per- and polyfluoroalkyl substances (PFAS) are a class of chemicals that have become widespread and persistent pollutants due to their extensive use in numerous consumer products and unique chemistry. PFAS have been detected in the serum of an overwhelming majority of people in the U.S. as well as in wildlife and waterways. There is substantial evidence that exposure to PFAS is linked with multiple adverse health effects, including altered immune function. Due to the vast number of PFAS that lack sufficient immunotoxicity data, there is significant need for new high-throughput screens that can rapidly assess how PFAS exposure impacts the immune system. Zebrafish (Danio rerio) are an established experimental model used in translational toxicology and have proved to be a versatile tool for studying the effects of PFAS exposure. Zebrafish embryos and larvae offer several advantages over mammalian models including: rapid embryonic development that is external to the mother, optically translucent embryos, ease of handling, genetic manipulability, and higher-throughput capabilities. Two immunology-focused transgenic zebrafish lines were utilized for these experiments: Tg(NFkB:EGFP), which expresses a general marker for immune stimulation, and Tg(lyz:GFP), which expresses fluorescently labeled neutrophils. Larvae were exposed to different PFAS for a total of 5 days and were imaged at 3, 4, and 5 days post fertilization to assess larvae morphology and measure either fluorescence intensity in the Tg(NFkB:EGFP) larvae or neutrophil number in the Tg(lyz:GFP) larvae. Preliminary results indicate that multiple PFAS tested induce at least some degree of immunotoxic effects in larval zebrafish. However, the exact pattern of these effects differs amongst the PFAS tested. Since PFAS are an exceptionally large and diverse class of chemicals, individual PFAS can have potentially varying effects and toxicity levels. This further highlights the importance of high throughput screens such as this for assessing PFAS immunotoxicity.

Disclaimer/Disclosure: This work is supported by the NCSU Center for Environmental & Health Effects of PFAS, NIH P42-ES031009. E.M.W.H was supported by the NCSU Toxicology Training Grant, NIH T32-ES007046. Acquisition of the MCAM was supported by an Innovation Impact Grant from the North Carolina Biotechnology Center.

1.08.P-We174 Occupational Exposure to Gas Turbine Emissions Is Associated With Altered Hematological Biomarkers in Nigerian Power Plant Workers

CAROLYN EKPRUKE[1] and Vincent Iyawe[2] (1)University of Benin, Nigeria and Taylor University, Upland, USA, (2)University of Benin, Nigeria

Gas-fired power plants are important sources of occupational exposure to combustion-derived air pollutants, including nitrogen oxides, volatile organic compounds, benzene, and particulate matter. While the respiratory effects of these pollutants are well documented, less is known about their long-term systemic effects on hematological health. This study evaluated whether chronic occupational exposure to gas turbine emissions alters hematological biomarkers associated with immune function and oxygen transport. A cross-sectional study was conducted among 440 adults, including 228 power plant workers and 212 unexposed controls, at a major gas-fired power generation facility in Nigeria. Participants completed exposure and health questionnaires, and blood samples were analyzed using an automated hematology analyzer. White blood cell (WBC), lymphocyte, monocyte, eosinophil, red blood cell (RBC), hematocrit, hemoglobin, and platelet counts were compared between exposed and control groups and further evaluated by years of exposure and work location. Power plant workers exhibited significant hematological alterations compared with controls ($p < 0.05$). In males, WBC counts decreased from 5.33 ± 0.02 to 4.50 ± 0.01 $\times 10^3/\mu L$, lymphocytes from 2.57 ± 0.03 to 1.79 ± 0.00 $\times 10^3/\mu L$, RBC counts from 5.63 ± 0.24 to 4.49 ± 0.43 $\times 10^6/\mu L$, hemoglobin from 15.43 ± 1.19 to 11.25 ± 1.11 g/dL, and platelet counts from 324 ± 14.33 to 207 ± 23.2 $\times 10^3/\mu L$. Similar reductions were observed in females. In contrast, eosinophil counts increased significantly in exposed workers. Workers with more than 10 years of exposure exhibited the greatest reductions in WBC, RBC, hemoglobin, hematocrit, and platelet counts, indicating a duration-dependent effect. These findings demonstrate that chronic exposure to gas turbine emissions is associated with immune dysregulation, systemic inflammation, and impaired hematopoietic function. The study highlights the need for improved occupational health surveillance and exposure mitigation strategies in power generation facilities, particularly in regions with rapidly expanding energy infrastructure.

Immunotoxicology: From Cells to Organisms

1.08.V-01 Xenobiotic Receptor Governs Gut Immunometabolic Adaptation in Soil Nematodes

Juil Kim[1], Ki-Hyung Kim[2] and Yuseok Moon[3] (1)Department of Convergence Medical Sciences and Biomedical Research Institute, Pusan National University, Yangsan, Korea, (2)Department of Obstetrics and Gynecology and Biomedical Research Institute, College of Medicine, Pusan National University, Pusan National University, Busan, Korea, (3)Laboratory of Food Systems Analytics, Department of Data Science, School of Data Science, Pusan National University, Busan, Korea

The intestinal barrier is a central interface linking nutrient absorption, microbial homeostasis, and immune regulation. Caloric restriction is widely recognized to improve metabolic health, yet the molecular mechanisms by which it enhances intestinal resilience remain incompletely defined. In particular, how environmental sensing pathways integrate metabolic stress to regulate gut function is not well understood. Here, we investigated the role of a conserved xenobiotic receptor (XnR), a key sensor of environmental and metabolic cues, in mediating intestinal adaptation to caloric restriction using a soil nematode model. Wild-type and XnR-deficient animals were subjected to ad libitum feeding, intermittent fasting, or complete food deprivation. In

wild-type animals, intermittent fasting significantly improved intestinal barrier integrity, as evidenced by reduced permeability and decreased bacterial burden, alongside enhanced mitochondrial function and reduced oxidative stress. Strikingly, these fasting-induced benefits were largely abolished in XnR-deficient animals, which displayed increased intestinal leakage, elevated bacterial colonization, and exacerbated mitochondrial oxidative stress under nutrient stress conditions. These findings identify XnR as a critical mediator of adaptive gut responses to caloric restriction. Mechanistically, our results support a model in which xenobiotic sensing is integrated with metabolic stress signaling to coordinate mitochondrial function and barrier homeostasis at the gut interface. This study provides a framework for understanding how environmental sensor pathways regulate intestinal resilience and highlights xenobiotic receptor–dependent signaling as a key axis linking metabolic adaptation to gut health.

Disclaimer/Disclosure: It was supported by the Basic Science Research Program through NRF Korea, funded by the Ministry of Education (2018R1D1A3B05041889, RS-2023-00240942, and RS-2024-00462450).

1.08.V-02 Ribosomal Protein–Linked Translational Stress Shapes Proinflammatory Responses to Deoxynivalenol in Human Cells

Ki-Hyung Kim[1], Juil Kim[2] and Yuseok Moon[3] (1)Department of Convergence Medical Sciences and Biomedical Research Institute, Pusan National University, Yangsan, Korea, Department of Obstetrics and Gynecology and Biomedical Research Institute, College of Medicine, Pusan National University, Pusan National University, Busan, Korea, (2)Department of Convergence Medical Sciences and Biomedical Research Institute, Pusan National University, Yangsan, Korea, (3)Laboratory of Food Systems Analytics, Department of Data Science, School of Data Science, Pusan National University, Busan, Korea

Deoxynivalenol (DON), a trichothecene mycotoxin produced by Fusarium species, is a widespread contaminant of agricultural environment and commodities. In addition to inhibiting protein synthesis, DON induces translational stress responses that are increasingly linked to intestinal inflammation; however, the mechanisms connecting ribosomal perturbation to epithelial immune signaling remain incompletely defined. Here, we investigated the role of ribosomal proteins in regulating chemokine responses in DON-exposed intestinal epithelial systems using integrated transcriptomic and experimental approaches. Our data identify a functionally divergent role for RPL13A and RPS3 in shaping inflammatory outputs under translational stress conditions. RPL13A was associated with attenuation of inflammatory signaling, consistent with engagement of stress-adaptive transcriptional programs, whereas RPS3 contributed to enhanced chemokine expression through activation of stress-responsive signaling and post-transcriptional regulatory processes. These findings suggest that DON-induced translational stress is not solely a consequence of ribosomal inhibition but is actively interpreted through ribosomal protein–dependent regulatory modules. The opposing roles of RPL13A and RPS3 define a tunable axis that may influence epithelial sensitivity to environmental toxin exposure. Collectively, this work provides a mechanistic framework linking dietary mycotoxin exposure to intestinal inflammatory signaling while highlighting ribosomal proteins as context-dependent modulators of environmental stress responses.

Disclaimer/Disclosure: It was supported by the Basic Science Research Program through NRF Korea, funded by the Ministry of Education (2018R1D1A3B05041889, RS-2023-00240942, and RS-2024-00462450).

Innovations in Environmental Toxicology to Advance the 3Rs

1.09.T.A-01 Integrating New Approach Methodologies To Inform Chronic Fish Hazard: A HESI Case-Study

Julie Krzykwa[1] and HESI Global Next Generation EcoRisk Committee Alternatives to Chronic Fish Testing Working Group[1] (1)HESI Global

Chronic fish toxicity testing is intended to support environmental protection, but current approaches often default to generating in vivo fish early-life stage (FELS) data, even when other relevant information may be available. At the same time, there is growing regulatory and public pressure to use new approach methodologies (NAMs) whenever possible. The HESI Global Next Generation EcoRisk Committee's Alternatives to Chronic Fish Testing Working Group is developing a case-study-based framework to evaluate how existing information and NAM data can inform chronic fish toxicity assessment. Rather than treating NAMs as one-for-one replacements for traditional tests, this work focuses on integrating multiple lines of evidence to determine whether in vivo testing is needed or whether NAM data are sufficient for the problem context, given the available data.

The framework is organized into 2 phases. Phase 1 asks whether chronic fish toxicity is likely to be a priority based on predicted environmental fate, adsorption, distribution, metabolism, and elimination. When fish-specific chronic toxicity data are needed, Phase 2 proposes evaluating all available evidence, including physicochemical properties, environmental fate/exposure information, bioaccumulation and toxicokinetic data, existing ecotoxicity studies, analog/read-across information, in silico predictions, in vitro assays, and mechanistic data, based on their reliability, applicability, consistency, and uncertainty.

The framework is being evaluated through case studies of chemicals with existing chronic fish data, enabling NAM-informed conclusions to be compared with traditional in vivo outcomes. The initial case studies will help inform which evidence is most informative, where uncertainty is too high for decision-making, and what additional data would increase confidence. This work will evaluate how NAMs and existing data can be used to support chronic fish hazard assessment, identify key sources of uncertainty, and clarify when in vivo testing is still needed. The expected outcome is guidance on a transparent approach for using NAMs and existing data while prioritizing vertebrate testing where it adds value.

1.09.T.A-02 Use of OECD Test Guideline 425 To Implement Reduction, Replacement, and Refinement (3R) in Mammalian Oral Toxicity Studies

Meredith Bohannon[1] (1)U.S. Defense Centers for Public Health

The median lethal dose (LD50) has long served as a benchmark of oral toxicity in mammalian studies, frequently conducted in rats. Numerous methods exist for LD50 determination, including the alternate lethal dose method, Organisation for Economic Cooperation and Development Test Guideline (OECD TG) 420, OECD TG 423, and the sequential stepwise probit method described in ASTM E1163. Most of these approaches sacrifice precision or accuracy to reduce animal numbers or, conversely, require large numbers of animals to attain high precision or accuracy. The present investigation applied OECD TG 425 (Acute Oral Toxicity: Up-and-Down Procedure) to estimate the LD50 of a test compound, with the dual aim of minimizing

animal use while achieving a precise LD50 and a narrow confidence interval. Following the guideline—which permits a maximum of 15 animals per sex—the investigators modulated the doses tested within guideline parameters to maximize information yield while using as few animals as possible. This was accomplished using the AOT425 software, available through the United States Environmental Protection Agency, to model outcome scenarios with doses that differed from the software's recommendations yet remained within guideline parameters. Prior to dosing, iterative testing indicated that most scenarios required an average of 9 animals and no more than 12 when a steep toxicity curve was assumed. Application of this approach to the test chemical, combined with continued scenario modeling between successive dosing rounds, required only five male and seven female rats, yielding a male LD50 of >2000 mg/kg and a female LD50 of 1505 mg/kg (95% confidence interval, 1620–1820 mg/kg). This combination of high precision and low animal use positions OECD TG 425 as a frontrunner for advancing implementation of the 3Rs in toxicity testing.

1.09.T.A-03 An Approach for Selecting Analogs To Support Environmental Hazard Assessments Under Toxic Substances Control Act (TSCA)

Jennifer Brennan[1], Sarah Au[1], Nicholas Turner[1], Tyler Amrine[1], James Bressette[1], Janet Burris[1], Kellie Fay[1], Janine Fetke[1], Patricia Fontenot[1] and Karen Eisenreich[1] (1)U.S. Environmental Protection Agency (US EPA)

For chemicals lacking empirical data, read-across methodologies are often used to identify analogs as part of the risk assessment process. The analogs' structural similarity, physical and chemical properties, environmental fate, and in vivo considerations (e.g., hazard and/or absorption, distribution, metabolism, and excretion) are compared to those of the chemical of interest when determining whether analog information should be utilized for the purpose of hazard characterization. Within US EPA's Office of Pollution Prevention and Toxics (OPPT), analog data are important for environmental hazard assessments of both new and existing chemical substances assessed under sections 5 and 6 of the Toxic Substances Control Act (TSCA) when critical data gaps exist. The use of analogs and other read-across approaches may enable EPA to more quickly conduct risk assessments for both new and existing chemicals. This presentation will provide an overview of OPPT's approach to selecting analogs for the characterization of environmental hazard, using case studies (e.g., trigonelline and 1,1-dichloroethane) to demonstrate its application within the new and existing chemicals programs. The presentation will emphasize how multiple factors (e.g., environmental fate and mode of action) may be considered when synthesizing analog information to support a robust read-across approach. One of the highlighted read-across approaches includes, but is not limited to, analog screening methodologies (e.g., Cheminformatics Modules and GenRA) used to quickly identify relevant and appropriate analogs with data that may be used for risk assessments. A goal of this presentation is to share how OPPT has refined its approaches for higher quality analog selection, and how this has reduced uncertainties associated with read-across of environmental hazard information to evaluate chemicals under TSCA. Following the presentation, attendees will have a better understanding of the strengths, challenges, and applications when using read-across methodologies and chemical categorization for TSCA risk assessments.

Disclaimer/Disclosure: Disclaimer: The views expressed in this session are those of the authors and do not necessarily represent the views or policies of the US Environmental Protection Agency.

1.09.T.A-04 Regulatory Applications of Environmental NAMs: Examining the Current

Landscape Across Multiple Markets and Agencies

Emma Sharpe[1] and Jennifer Collins[1] (1)Bowman Consulting Group

New Approach Methodologies (NAMs) are increasingly promoted as tools to improve efficiency, mechanistic relevance, and ethical considerations of environmental risk assessment. While substantial effort has focused on the development and validation of NAMs, less attention has been given to their practical application within regulatory decision-making. As a result, uncertainty remains regarding the circumstances under which NAM-derived information is accepted, challenged, or incorporated into environmental assessments across regulatory frameworks.

Drawing on experiences from pesticides, industrial chemistry and pharmaceutical registration programs, this presentation examines how environmental NAMs have been applied in regulatory submissions and reviews. Case studies will illustrate the use of approaches including quantitative structure–activity relationships (QSARs), read-across, mechanistic and mode-of-action information, exposure-based waivers, and other non-traditional data sources to support environmental fate and ecotoxicological assessments. Examples will highlight situations in which NAM-derived information successfully informed regulatory decisions, supported weight-of-evidence evaluations, or contributed to testing strategies, as well as instances where limitations in applicability, transparency, or uncertainty characterization reduced regulatory utility.

The presentation will further compare how environmental NAMs are evaluated across different regulatory sectors and frameworks. Although acceptance criteria and regulatory flexibility vary, common themes are emerging regarding documentation, scientific justification, applicability domain considerations, and integration with conventional study data.

As scientific innovation continues to outpace formal guidance development, understanding how regulators interpret and apply NAM-derived information is becoming increasingly important for registrants, regulators, and contract research organizations. This presentation will provide practical insights into current regulatory expectations and discuss opportunities for broader integration of environmental NAMs into future environmental risk assessments.

1.09.T.A-05 Building Confidence in the Use of Transcriptomic Points of Departure for Regulatory Decision-Making: A Case Study With a 24-Hour Rainbow Trout Alevin Assay

Rebecca Dalton[1], Jessica Head[2], Emily Boulanger[2], Hugo Marchand[2], Krittika Mittal[2], Ke Xu[2], Aylish Marshall[2], Florence Pagé-Larivière[1], Doug Crump[1] and Niladri Basu[2] (1)Environment and Climate Change Canada (ECCC), (2)McGill University

Recent amendments to the Canadian Environmental Protection Act, 1999 (CEPA) include recognition of the need to replace, reduce or refine the use of vertebrate animals in toxicity testing and resulted in the publication of a strategy to guide continued efforts to reduce reliance on vertebrate animals. Efforts to implement the strategy include the development, standardization and incorporation of new approach methods (NAMs), including embryo-larval fish assays, into risk assessment activities. This presentation will highlight a case study from a partnership between academic researchers and government regulatory end-users that aims to overcome barriers to the integration of NAMs into risk assessment activities. The objective was to establish a

transcriptomic-based, high-throughput toxicity test method for embryo-larval fish that yields data comparable to both acute (i.e., 96-hr LC50s) and chronic (i.e., long-term, sub-lethal) fish toxicity tests. Rainbow trout alevins (~1 day post-hatch) were placed in individual wells (24-well plates) and exposed for 24 hr to 12 different concentrations per chemical. To date, 39 chemicals with diverse physical and chemical properties have been studied, including negative controls. Results indicate good concordance between acute toxicity data generated from the case study and apical data from the U.S. EPA ECOTOX Knowledgebase. Sequencing data were obtained for 33 chemicals and transcriptomic points of departure (tPODs) were derived as a potential estimate of chronic toxicity. For each chemical, a tPOD (either mode, 10th percentile, or 20th gene) was calculable, with tPOD mode values ranging from 0.008 to 1,500 mg/L. Currently we have fish chronic toxicity data for 15 chemicals, with a statistical association between the tPODs data obtained here (i.e., 24-hr assay with fish embryos) and fish chronic toxicity data (i.e., whole animal studies that are at least 21 days in duration). The findings thus far are promising in terms of establishing a new test method, though work continues to expand our sequencing efforts to yield more tPOD data, test more compounds, expand the fish acute/chronic data, and continue discussions between academic and government partners.

1.09.T.A-06 Advancing Effluent Toxicity Testing With Early-Life Stage Tests and Transcriptomics

Seetal Dhaliwal[1], Krittika Mittal[1], Ke Xu[1] and Niladri Basu[1] (1)Department of Natural Resource Sciences, McGill University

In Canada, acute toxicity tests with rainbow trout are used to evaluate potential impacts of effluents on aquatic systems. However, these animal tests raise ethical concerns, are costly and time intensive, and provide limited information on sub-lethal effects. In response, new approach methods (NAMs) are being developed to guide the replacement, reduction, and refinement of animal tests to support regulatory requirements. Among these approaches, early life stage (ELS) assays and transcriptomics have shown promise in toxicity assessment. ELS assays may yield data that is comparable to juvenile or adult fish tests, with lethal concentration 50 (LC50) values being comparable for single chemicals. Transcriptomic data can be used to provide mechanistic information and can also be subject to dose-response modeling to yield transcriptomic point of departure (tPOD) values. tPODs derived from acute studies have demonstrated good concordance with benchmark doses in chronic studies. While these approaches are of interest, they have largely focused on single chemical evaluations. Limited studies have applied these tools to complex environmental mixtures such as effluents. Here, the objectives of this study were to: A) prepare four mock effluents in the laboratory representing common scenarios in Canadian ecosystems: stormwater, pharmaceuticals and personal care products (PPCPs), oil and grease, and metal mines; B) expose rainbow trout alevins to 11 concentrations of each effluent spanning seven orders of magnitude, and then determine LC50 values; C) evaluate and compare transcriptomic responses using UPXome (RNA-seq) and EcoToxChips (targeted qPCR arrays). The upper test concentrations of mixture constituents were identified based on regulatory limits and/or monitoring data. LC50 values were obtained for all effluents except for the PPCPs mixture. Both negative and positive controls (3-4 dichloroaniline) passed quality control measures. Sequencing is complete, and data analysis is ongoing to determine tPODs and pathway responses. The results of this study aim to support new methods aligned with the 3Rs to help environmental monitoring and toxicity testing of effluents transition to a more ethical, informative, predictive, and economic practice. To our knowledge, this study represents one of the first applications of an ELS rainbow trout assay and tPODs to study mock effluents.

Innovations in Environmental Toxicology to Advance the 3Rs

1.09.T.B-01 Establishment and Characterization of a Japanese Quail Hepatic Cell Line for Avian Toxicity Testing

Tasnia Sharin[1], Jason O'Brien[1] and Doug Crump[1] (1)Environment and Climate Change Canada (ECCC)

Regulatory agencies of several countries are adopting frameworks to reduce animal use and incorporate new approach methodologies for toxicity testing. Japanese quail (JQ, Coturnix japonica) is a common model for avian toxicity testing, especially for
pesticide registration. Immortalized hepatic cell lines reduce the reliance on animals for toxicity testing; however, there are currently no commercially available JQ hepatic cell lines. In this study, an immortalized JQ hepatic cell line, HepaNix-15, was established
from the liver of a day 15 male embryo. HepaNix-15 cells were cultured for over a year and have hepatocyte-like morphology. Induction of CYP1A activity was observed following exposure to PCB-126, benzo(a)pyrene and β-naphthoflavone in the cells.
Exposure to hexabromocyclododecane, metyrapone and carbamazepine induced CYP3A activity. There was an increase in transthyretin, deiodinase II, and vitellogenin protein levels following exposure to thyroxine or 17β-estradiol. Overall, the results
suggest that the immortalized JQ cell line has functional xenobiotic metabolism (e.g. CYP1A and CYP3A activity) and thyroid and estrogen response signaling, supporting its potential use as an alternative in vitro model for avian toxicity testing.

1.09.T.B-02 Exploring the Applicability of the OECD TG 249 Fish Cell Line Acute Toxicity Assay in Environmental Hazard and Risk Assessment of Cosmetic Product Ingredients

Giacomo Grassi[1], Kyle Roush[2], Alejandra Bouzas Monroy[3], Bruno Campos[4], Christopher Fassbender[5], Beta Montemayor[6], Takahiro Suzuki[7], Helena Villuendas Garcia[8], Roman Li[8], Ryan Heisler[9] and Amelie Ott[9] (1)L'Oreal, (2)Procter & Gamble, (3)Croda International Plc, (4)Unilever, (5)PETA Science Consortium International e.V., (6)Cosmetics Alliance Canada, (7)Kao Corporation, (8)aQuaTox-Solutions GmbH, (9)International Collaboration on Cosmetics Safety (ICCS)

The OECD Test Guideline (TG) 249, based on the RTgill-W1 fish gill cell line, provides a key advancement for predicting acute fish toxicity without the use of animals. As the application of OECD TG 249 becomes more widespread, efforts are on-going to define its chemical applicability domain thus strengthening hazard characterization as a standalone method or as part of integrated approaches to testing and assessment (IATAs). On-going initiatives are contributing to the systematic evaluation of OECD TG 249 performance across diverse chemical classes, identifying areas of strong concordance with historical in vivo data and supporting regulatory interpretation and acceptance.

Building on these efforts, the International Collaboration on Cosmetics Safety (ICCS) has launched a project using a diverse set of cosmetic ingredients, spanning a range of physicochemical properties and uses to further define the chemical applicability domain of the OECD TG 249 and to better understand assay performance across relevant substance types.

OECD TG 249 results are systematically reviewed and compared with available high-quality historical in vivo acute fish toxicity data. We are evaluating predictive accuracy across chemical classes, identifying areas of strong alignment between in vitro and in vivo outcomes, and identifying important lessons on specific chemistries requiring further refinement to improve predictive performance. These outcomes will strengthen the understanding of the assay's chemical domain of applicability and support its integration into existing environmental risk assessment frameworks.

Disclaimer/Disclosure: This project was funded by the International Collaboration on Cosmetics Safety

1.09.T.B-03 Comparing In Vitro Neurotoxicity Assessments to In Vivo Studies Using Rainbow Trout Fish (Oncorhynchus mykiss)

Emma Veres[1], Krittika Mittal[2], Ke Xu[1], Sophie Emberley-Korkmaz[1] and Niladri Basu[1] (1)McGill University, (2)No Affiliation

The Organization for Economic Cooperation and Development (OECD) has standardized the cytotoxicity test guideline number 249 using rainbow trout gill cells (RTgill-W1) as a substitute for fish acute toxicity testing. Although validation studies have demonstrated biological relevance through concordance with in vivo outcomes for a variety of diverse compounds, chemicals with a neurotoxic mode of action have demonstrated weaker concordance with values differing by more than one order of magnitude. The present study aims to enhance the OECD guideline 249 to more accurately measure the acute toxicity of chemicals with a neurotoxic mode of action by adapting this guideline to support the use of the rainbow trout brain (RTBrain) cell line. In addition to assessing acute toxicity, transcriptomic points of departure (tPODs) derived from RTgill-W1 cells have been shown to correlate with apical measures from chronic fish studies. The three objectives of this study were to (1) Assess cytotoxicity by deriving the half-maximal concentration (EC50) in the RTBrain cell line following 24-hour exposure to a total of 12 chemicals. (2) Derive tPODs using the effective concentration 20 (EC20) as the highest concentration. (3) Qualitatively assess morphological changes in the RTBrain cell line using confocal microscopy following exposure to each chemical. Cells were exposed for 24-hrs following which cytotoxicity was assessed to derive EC50 values and then compared with acute fish toxicity lethal concentration (LC50) values. All neurotoxic chemicals induced cytotoxicity in RTBrain cells, with one of the negative controls, ibuprofen, also exhibiting measurable effects. Of the ten compounds yielding EC50 values, 90% were less than 5-fold different with corresponding in vivo LC50 values, demonstrating a strong correlation between LC50 and EC50 values. Lindane (186-fold decreased sensitivity) was a notable outlier. Studies are underway to calculate tPODs and correlate them to apical measures from chronic whole-fish assays from the literature. Finally, morphological effects will be evaluated through immunohistochemistry for F-actin and MAP1B proteins following exposure to the test chemicals. Overall, these findings are projected to increase understanding of the RTBrain cell line as a neurotoxicity model, and its use as a suitable model to assess outcomes in fish acute and chronic toxicity studies.

1.09.T.B-04 Systematic Evaluation of Phenotypic Responses in the Embryonic Zebrafish Developmental Toxicity Assay: A Case Study of Vehicle and Positive Controls

Bridgett Hill[1], Bridget Knapp[2], Jui-Hua Hsieh[3], Jonathan Hamm[2], Emily Reinke[1], Helena Hogberg[3] and Kristen

Ryan[3] (1)General Dynamics Information Technology, Inotiv, (2)Inotiv, (3)NIH/NIEHS/DTT

Embryonic zebrafish developmental toxicity screening is often performed using different experimental protocols, with toxicity frequently reported as combined mortality and phenotypic abnormalities. However, data on individual phenotypic alterations can provide valuable insight for chemical hazard assessments and inform on the mechanisms of action. In addition, inconsistency in the terminology used across laboratories to describe phenotype alterations make cross-study comparison difficult. To address these issues, an interlaboratory study involving three laboratories (Labs A, B, and C) evaluated 42 chemicals at multiple concentrations under four combinations of experimental conditions: embryos with intact or removed chorions and chemical exposure using either static or static-renewal protocols. Single zebrafish embryos at 4-6 hours postfertilization were placed in 96-well plates and exposed for 5 days to either blinded chemicals, the positive control substance (3,4-dichloroaniline [DCA]), or the vehicle control (0.5% dimethyl sulfoxide [DMSO]). Laboratory-specific phenotype terms were annotated and grouped by anatomical region to facilitate cross-laboratory comparisons. Variability in phenotype incidence was assessed within and between laboratories under varying experimental conditions after treatment to positive and vehicle controls. Benchmark concentration (BMC) values for DCA varied from 3–45 μM across laboratories and protocols. For DCA, head defects were the most altered phenotype across laboratories. Lower BMCs were observed for all phenotypes under static-renewal conditions in Labs A and B. Evaluations of vehicle-treated embryos also demonstrated variability across laboratories and experimental conditions. Lab C reported a higher incidence for altered phenotypes (0–16% affected) compared to Labs A and B (0–3% affected), with minimal differences among experimental conditions. These results highlight existing variability within and across zebrafish testing protocols and the need for standardized methods. Moreover, the results emphasize the value of evaluating phenotype endpoints, as these endpoints can help inform mechanisms of action.

Disclaimer/Disclosure: This project was supported by the Intramural Research Program (ES#103386) at NIEHS, NIH (contract HHSN273201500010C [Inotiv]) and DPCPSI, NIH (contract GS-35F-393CA - 75N94025F00103 [GDIT]). The views expressed above do not necessarily represent the official positions of any federal agency.

1.09.T.B-05 A Phenotypic Approach to Interpreting Amphibian Metamorphosis Assays: Endpoint Response Patterns Facilitate Read-Across To Minimise In Vivo ED Testing for Plant Protection Products

Daniel Pickford[1] and Jacqueline Augusiak[2] (1)Syngenta Ltd, (2)Syngenta Seeds BV

Read-across is regarded as a strategy to reduce animal testing for chemical safety assessment: the OECD Conceptual framework (CF) for screening and testing of endocrine disruptors (EDs) includes read-across as relevant non-test information that may be available at Level 1. The amphibian metamorphosis assay (AMA; OECD 231, OPPTS 890.1100) is a short-term in vivo assay (CF Level 3) intended as a screen for thyroid activity. While the assay can respond to several modes of action relevant to thyroid disruption (e,g, blockade of the sodium-iodide symporter, inhibition of thyroperoxidase or deiodinase enzymes, (ant-)agonism of thyroid hormone receptor), the endpoints are apical and also sensitive to systemic and/or target organ toxicity. This presents a challenge if responses of individual endpoints are considered in isolation – according to OECD TG 231 small changes in hind limb length at only one time point are sufficient to warrant a positive result, which

may lead to unnecessary animal use through higher tier testing if ultimately a false positive. A more phenotypic approach to interpreting AMA studies is presented looking at endpoint response patterns in a dataset comprising publicly available AMA data conducted for the US EPA EDSP, OECD validation assays, and (anonymised) proprietary data on plant protection active substances. Endpoints were categorised as informing on: (i) overt toxicity, (ii) growth or (iii) development. This dataset was then interrogated for phenotypic patterns associated with indication, structural class, or known toxicological mode of action. These findings indicate that very few plant protection actives exhibit response patterns comparable to known thyroid axis disrupters and for some classes e.g. conazoles, patterns indicative of systemic toxicity are clearly apparent. This approach offers the potential for preliminary assessment of active substances through read-across to inform choices on data generation supporting evaluation of thyroid-mediated activity in non-target organisms. In turn this may support greater use of in vitro or other non-animal testing approaches, with consequent reductions in animal use.

1.09.T.B-06 Effect-Based Monitoring at Scale – Insights From More Than 5,000 Measurements of Water Quality Using In Vitro Bioassays

Johan Lundqvist[1] and Agneta Oskarsson[2] (1)Swedish University of Agricultural Sciences (SLU), (2)Swedish University of Agricultural Sciences

This study reports conclusions and insights from more than 5,000 water quality measurements using effect-based methods. This uniquely large dataset highlights the added value of effect-based methods compared to chemical analysis and provides a valuable reference framework for interpreting future monitoring results.

Chemical pollutants in water threaten both aquatic ecosystem health and human health through potential drinking water contamination. Tens of thousands of pollutants have entered the environment, mixing with naturally occurring compounds to form complex and ever-changing mixtures.

Targeted chemical analysis is widely used in water quality monitoring, but it has inherent limitations: only compounds with known structures can be analyzed, leaving most environmental chemicals unmonitored. Since toxicological data are lacking for many contaminants, chemical analysis provides limited information on overall hazard and no insight into mixture effects. Regulated and routinely monitored pollutants typically explain only a small fraction of observed aquatic toxicity.

Effect-based methods, often based on cultured animal or human cells, respond to biological effects linked to toxicity, such as oxidative stress, genotoxicity and endocrine disruption. By integrating effects from all hazardous compounds present, including unknown chemicals and mixture interactions, they provide a measure of cumulative toxicity relevant to environmental and human health protection.

Here, we report results from one of the largest applications of effect-based water quality monitoring to date. More than 1,400 water samples were collected over six years, spanning untreated and treated wastewater, surface water and drinking water. Samples were analyzed using a panel of effect-based methods covering endocrine disruption, oxidative stress, aryl hydrocarbon receptor activation and genotoxicity. In total, more than 5,000 measurements were carried out.

The results demonstrate how effect-based methods can be implemented at scale within monitoring programs,

providing complementary information to chemical analysis and supporting early-warning detection of hazardous mixtures. Finally, we discuss result interpretation approaches, including effect-based trigger values (EBTs) and comparisons with large reference datasets, to support decision-making in water management and policy contexts.

Innovations in Environmental Toxicology to Advance the 3Rs

1.09.P-Tu116 Detecting Pulp and Paper Mill Effluent Toxicity Using the RTgill-W1 Assay

Jack Salole[1], Joanna Wilson[2] and Lisa Taylor[1] (1)McMaster University, Nautilus Environmental, (2)McMaster University

As test methods become more sophisticated, the complexity of toxicity test data becomes complex, and can consist of multiple endpoints across many technical and/or biological replicates. Currently, these values are used to determine effect measures (i.e. LC50, IC25) through dose-response modelling. While this process is well understood and can be completed with various programs, consistently applying it over many tests or experimental subsets is a tedious process. The 'toxdrc' package is being developed to address this limitation of current techniques. This package provides a set of modular functions that can ingest raw data, perform quality checks, apply user-specified transformations, fit and select the best fitting dose-response model, and get the specified point estimates across multiple experimental subsets. Importantly, these modular functions are combined into a pipeline function that allows this process to be automate the analysis of large datasets. This package is designed to support both quantal and quantitative endpoints, making it adaptable to diverse test measurements. This package is particularly well-suited for researchers working with large-scale toxicity studies that require efficient, consistent, and transparent data processing across large datasets. Publicly available versions of this package are currently being applied in research contexts to estimate effect measures. Here, we present an overview of the package and a case study using this package to rapidly analyze toxicity data from a dataset with 300 unique experimental subsets in under 5 minutes.

1.09.P-Tu117 Advancing Non-Lethal PFAS Biomonitoring in Fish Using a Blood Microsampling Technique

Sara Hutton[1] and Kenia Whitehead[1] (1)GSI Environmental

Site-specific human health and ecological risk assessments for per- and polyfluoroalkyl substances (PFAS) routinely rely on lethal collection of fish to quantify tissue concentrations in fillet and whole-body. Unlike legacy lipophilic contaminants, PFAS bind extensively to circulating serum proteins, particularly albumin, rather than to lipids, making blood a mechanistically relevant matrix for characterizing PFAS exposure in fish. Volumetric absorptive microsampling (VAMS) collects a fixed, low volume of whole blood with minimal handling, offering a non-lethal alternative to whole-animal sampling and aligning with efforts to reduce and refine vertebrate animal use in environmental assessment.
During a field investigation at a PFAS-impacted site, we used Mitra VAMS devices to collect blood from four fish species of fish. The collected fish fall into two groups, lower trophic level omnivores with smaller body sizes (≤8), and secondary or tertiary consumers with larger body sizes (>8). Small fish (rock bass and bluegill) were analyzed as whole-body samples, whereas larger fish (smallmouth bass and largemouth bass) were

dissected into three compartments: skin-off fillet, stomach, and remaining carcass plus viscera. Co-located surface water and sediment samples were also collected to characterize exposure conditions. The objective of this study was to evaluate whether PFAS concentrations in blood can predict concentrations in fillets and whole body across species and tissue compartments. Establishing robust blood-to-tissue relationships would allow practitioners to estimate risk-relevant tissue concentrations of fish from a single, minimally invasive blood sample, substantially reducing, and potentially replacing, lethal fish collection in PFAS site investigations. This presentation describes the field sampling design, blood-to-tissue modeling approach, and discusses how VAMS-based blood monitoring could advance the 3Rs while preserving the quantitative foundation for ecological and human-health risk assessment.

1.09.P-Tu118 Assessing In Vitro Skin Irritation of a Test Solvent Using a Reconstructed Human Epidermis Model

Jorge Ruiz[1] (1)U.S. Defense Centers for Public Health

This study evaluated the skin irritation potential of a novel test solvent using an in vitro reconstructed human epidermis (RhE) model. Experiments were conducted using the MatTek EpiDerm™ Skin Irritation Test in accordance with Organization for Economic Co-operation and Development Test Guideline 439 (OECD TG 439), a validated non-animal method that assesses chemical-induced skin irritation by quantifying effects on tissue viability.

The RhE model is a three-dimensional tissue of human-derived skin cells. The test compound was applied directly to the tissue surface, and tissue viability was determined using the 3-[4,5-dimethylthiazol-2-yl]-2,5-diphenyltetrazolium bromide (MTT) assay. Under the Globally Harmonized System (GHS) prediction model used for this assay, a mean tissue viability of ≤50% is classified as an irritant, while viability above 50% is classified as a non-irritant. Two independent experiments were performed. The first experiment followed the standard OECD TG 439 procedure to derive a mean relative tissue viability of 51.3%, which was marginally above the irritant cutoff and thus classified as a non-irritant. Due to the proximity to the 50% decision threshold and the presence of visible oily residue after rinsing – suggesting incomplete removal of the test compound – a second experiment was performed. The protocol was modified to include an additional rinsing procedure with warm Dulbecco's Phosphate-Buffered Saline (DPBS) and an equilibration step to improve removal of residual surface-associated material. This adjustment resulted in a mean relative tissue viability of 59.0%, supporting a more definitive non-irritant classification.

Preliminary assay compatibility testing showed that the test compound did not directly reduce MTT or interfere with the absorbance measurement. Both experiments met the required assay acceptance criteria, including acceptable negative and positive control responses and low variability among tissue replicates. Overall, the proprietary/test solvent did not induce skin irritation in the RhE model. Future work will explore the observed reduction in viability relative to the negative control, as this may reflect mild tissue stress under certain exposure conditions.

1.09.P-Tu119 The Unintended Filter: Organic Ultraviolet Filters Inhibit Thyroperoxidase Enzyme Activity in Red Drum (Sciaenops ocellatus) Microsomal Fractions

Vann Boyte[1], Lauren Eagon[1], Christopher Lowrey-Dufour[2] and Jon Doering[2] (1)Louisiana State University Baton Rouge, (2)Louisiana State University

Organic ultraviolet (UV) filters are synthetic chemicals that absorb and reflect UV light. These chemicals are commonly found in sunscreens and cosmetics to protect skin, as well as in industrial and consumer products to prevent photodegradation. However, UV filters are frequently detected in aquatic environments due to recreational water use and wastewater discharge. Several organic UV filters have been identified as potential endocrine-disrupting chemicals, with evidence they interfere with thyroid hormone signaling. Because thyroid hormones regulate vertebrate growth, development, metabolism, and reproduction, disruption of these pathways can have ecological consequences. The primary objective of this study was to evaluate the potential of organic UV filters to inhibit thyroperoxidase (TPO) activity, a key enzyme for thyroid hormone synthesis. TPO activity was measured using the Amplex UltraRed thyroperoxidase assay (AUR-TPO) in renal microsomal fractions from adult red drum (Sciaenops ocellatus). This high-throughput assay, adapted from the U.S. Environmental Protection Agency ToxCast mammalian TPO assay, screens chemicals across a range of concentrations to generate concentration-response curves and determine inhibitory concentrations. Methimazole (MMI), a well-characterized inhibitor of TPO enzyme activity, served as the reference chemical for comparison of inhibitory potency. Previous studies have demonstrated conserved sensitivity to inhibition of TPO across fish species and vertebrate taxa, supporting the use of this assay for screening a suite of chemicals in a single species. Fifteen commonly detected organic UV filters were evaluated for inhibition of TPO. Of these, ten compounds inhibited TPO activity in-vitro, including five that were more potent inhibitors than MMI and five that were less potent but still produced measurable inhibition. Among the most potent inhibitors, benzophenone-2, octisalate, and benzophenone-1 were approximately 280-, 66-, and 30-fold more potent than MMI, respectively. The remaining five compounds did not produce measurable inhibition at the tested concentrations. These findings demonstrate that UV filters have the potential to disrupt thyroid hormone synthesis in fishes through the inhibition of TPO activity. The results highlight the utility of the AUR-TPO assay as an animal-alternative screening tool to identify thyroid-disrupting chemicals, supporting ecological hazard assessment.

1.09.P-Tu120 Omics-Enhancement of OECD236: Comparison of Transcriptomic Points of Departure in Zebrafish Embryos Exposed to Metals With Fish Chronic Toxicity Endpoints

Gemma Culotta[1], Hugo Marchand[1], Aylish Marshall[1], Krittika Mittal[1], Ke Xu[1], Rebecca Dalton[2], Florence Page-Lariviere[2], Doug Crump[2], Jessica Head[1] and Niladri Basu[1] (1)McGill University, (2)Environment and Climate Change Canada (ECCC)

OECD 236 Fish Embryo Acute Toxicity (FET) test is increasingly used as an alternative to traditional acute fish toxicity assays, though its ability to yield information relevant to chronic toxicity is limited. Recent evidence suggests that transcriptomic points of departure (tPOD) from short-term tests may yield data that can be used to estimate chronic toxicity. This study aims to enhance the OECD 236 FET test to generate exposure-response transcriptomics information, that may support chemical risk assessment activities by providing information on both acute and chronic fish toxicity. Here, we enhance the protocol in two main ways: A) in the standard 24-well plates, we double the chemical concentrations tested; and B) we explore a 24 hour test period, in 96-well

plates, after the zebrafish embryo has hatched from its chorion (i.e., between 72 and 96 hours post-fertilization). These methods are being tested using a group of metals (chromium, manganese, nickel, copper, zinc, cadmium, lead) that are present in aquatic ecosystems and have robust fish acute and chronic toxicity data. Test concentrations will be analytically verified. Preliminary studies have been performed on copper sulphate to yield LC50 and tPOD values. We expect these results to support the notion that tPODs from short-term tests in fish embryos yield points of departure comparable to those from fish chronic toxicity studies. In doing so, the work is expected to demonstrate how OECD236 may be enhanced with 'omics to yield more information relevant to support regulatory decision-making and scientific investigations.

1.09.P-Tu121 Developing a Strategy To Guide Efforts To Replace, Reduce or Refine Vertebrate Animal Testing Under the Modernized Canadian Environmental Protection Act, 1999 (CEPA)

Julie Loiselle[1], Rebecca Dalton[2], Tara Barton-Maclaren[1], Rebecca Bose[1], Kristin Eccles[1], Marisol Eggleton[2], Matthew Gagné[1], Sabina Halappanavar[1], Dominic Lambert[1], David Lefebvre[1], Alexandra Long[1], Jocelyn Moore[1], Deborah Ratzlaff[1], Florence Pagé-Larivière[2], Guillaume Pelletier[1], Joëlle Pinsonnault Cooper[1], Marie-Claude Sauvé[2] and Daryl Smith[1] (1)Health Canada, (2)Environment and Climate Change Canada (ECCC)

Health Canada (HC) and Environment and Climate Change Canada (ECCC) are responsible for assessing and managing risks from substances under the Canadian Environmental Protection Act, 1999 (CEPA). Amendments to CEPA in 2023 included several new provisions that aim to replace, reduce or refine the use of vertebrate animals in toxicity testing. To guide continued efforts to reduce reliance on vertebrate animal testing, HC and ECCC developed a strategy. An interdepartmental HC-ECCC team was formed to lead the strategy's development within a two-year timeframe. The team collaborated with internal and external partners to assess current efforts, define strategic goals, and identify key elements for action. Two public consultations were held: one on a notice of intent (November 2023), which received over 4,000 responses, and another on the draft strategy (September 2024), which received over 6,000 responses. Additional input was gathered through stakeholder engagements, both domestic and international. Building on this input, HC and ECCC published the strategy in July 2025. It comprises five core elements and guides the ongoing development and use of scientifically justified alternative approaches to replace, reduce or refine vertebrate animal testing under CEPA whenever possible. The five elements include 1) identifying and prioritizing NAMs for regulatory needs; 2) advancing NAMs research and data generation; 3) promoting harmonization and collaboration; 4) communicating and consulting with stakeholders; and 5) implementing NAMs in CEPA regulatory programs. This strategy marks a significant milestone in reducing reliance on vertebrate animal testing in chemical risk assessment activities under CEPA. It provides a framework for continued collaboration and innovation, with potential applicability beyond CEPA to other Canadian federal regulatory programs. As implementation progresses, sustained coordination and stakeholder engagement will be essential to ensure progress and impact.

1.09.P-Tu122 Characterizing Uncertainty in In Vitro-In Vivo Dose Extrapolation

Alessandro Sangion[1], James Armitage[2], Andy Nong[3], Tara Barton-Maclaren[3] and Jon Arnot[1] (1)Arnot Research & Consulting (ARC), (2)Armitage Environmental Sciences Inc. (AES), (3)Health Canada

Thousands of chemicals require regulatory evaluation, yet complete in vivo toxicity datasets are available for only a small fraction of substances, and generating new animal data at scale is neither practical nor consistent

with efforts to reduce vertebrate testing. New approach methods (NAMs), including in vitro bioassays, offer a promising alternative for chemical risk assessment; however, confidence is needed in their ability to translate in vitro bioactivity into biologically relevant in vivo dose metrics to support regulatory decision-making. Quantitative in vitro–in vivo extrapolation (Q-IVIVE) provides a framework for converting in vitro concentration–response data into equivalent in vivo doses, enabling direct comparison with toxicity and exposure data for risk-based chemical evaluations. This study presents a structured framework to systematically characterize and quantify key sources of uncertainty in Q-IVIVE dose extrapolation. The proposed approach integrates uncertainty analysis directly into the Q-IVIVE workflow through four steps: (1) defining mechanistic processes governing dose extrapolation, (2) identifying key sources of uncertainty, (3) quantifying uncertainty in critical parameters and models, and (4) propagating uncertainty to derive confidence bounds around administered equivalent doses (AEDs). The framework explicitly accounts for chemical disposition in in vitro systems, including volatility, solubility, and sorption to plastic, which influence free concentrations and may lead to substantial bias when nominal concentrations are used. The framework also emphasizes the importance of accurately characterizing in vivo TK parameters, such as biotransformation rates which are often dominant contributors to uncertainty and variability. In addition to improving transparency and confidence in Q-IVIVE, the approach facilitates identification of key drivers of uncertainty, thereby informing targeted data generation and Q-IVIVE method refinement through Integrated Approaches to Testing and Assessment (IATA). This proposed framework provides a practical foundation for integrating uncertainty of NAM data into risk-based evaluations and advancing the application of NAMs to support decision-making.

1.09.P-Tu123 Development and Application of an RTgutGC Cell-Based NAM for Dietary Toxicity Assessment

Yanan Zhang[1] and Niladri Basu[1] (1)McGill University

Fish cell-based New Approach Methodologies (NAMs) are increasingly being developed to reduce reliance on whole-fish toxicity testing. While current fish in vitro assays, including the RTgill-W1 assay described in OECD Test Guideline (TG) 249, primarily address waterborne exposure, dietary exposure remains an important route of chemical uptake in aquatic organisms. The objective of this study was to evaluate the rainbow trout gut cell line RTgutGC as a potential platform for dietary toxicity assessment.

Assay reproducibility was first evaluated using dichloroacetic acid (DCA) as a reference chemical. Three independent cytotoxicity experiments were conducted across multiple passages, and cell viability was assessed using Alamar Blue (AB), CFDA-AM, and Neutral Red (NR) assays following 24 h exposure. DCA produced reproducible concentration-response relationships across biological replicates, with LC50 values ranging from 55.6–58.0 mg/L, 90.4–91.6 mg/L, and 62.0–74.6 mg/L for AB, CFDA-AM, and NR assays, respectively.

The applicability of the assay was subsequently evaluated using methylmercury chloride (MeHgCl), a bioaccumulative contaminant relevant to dietary exposure. RTgutGC cells were exposed to nominal concentrations of 0, 0.102, 0.256, 0.640, 1.600, and 4.000 mg/L for 24 h following OECD TG 249 procedures. Calculated EC50 values were 0.234 mg/L (95% CI: 0.130–0.420 mg/L), 0.651 mg/L (95% CI: 0.496–0.854 mg/L), and 0.263 mg/L (95% CI: 0.073–0.948 mg/L) based on AB, CFDA-AM, and NR assays, respectively. Mercury concentrations were measured in exposure media at exposure initiation (0 h) and after 24 h of exposure. Preliminary analyses indicated recoveries of up to approximately 80% of nominal concentrations,

although additional analyses of exposure media and RTgutGC cells are ongoing.

These findings demonstrate that RTgutGC cells provide reproducible cytotoxicity responses and are sensitive to a dietary-relevant contaminant. This work supports the expansion of fish cell-based NAMs from waterborne to dietary exposure assessment and provides foundational data for future gut–liver–brain multi-cell-line co-culture systems aimed at improving the prediction of dietary toxicity while reducing reliance on whole-animal testing.

1.09.P-Tu124 The FACT Database: A Comprehensive Collection of Fish Acute Cell Toxicity Data

Marion Revel[1], Christoph Schür[1], Melanie Fischer[1], Christopher Faßbender[2], Uwe Schmitt[3], Gilly Stoddart[2] and Kristin Schirmer[1] (1)Swiss Federal Institute of Aquatic Science and Technology (Eawag), (2)PETA Science Consortium International e.V., (3)ETH Zürich

One of the barriers towards broader acceptance of New Approach Methods (NAMs) is a lack of confidence into, and understanding of, the capabilities of these assays. Such limitations are often due to the fact that not all relevant data is publicly available and an associated unclear definition of the applicability domain of the assay. The RTgill-W1 cell line acute toxicity assay is an alternative method for fish acute toxicity that has been validated and standardized as OECD Test Guideline 249. Its results have been shown to strongly correlate with fish acute mortality. In order to strengthen the confidence in this method and to characterize the continuously expanding applicability domain of the assay, we created the FACT (Fish Acute Cell Toxicity) database as a collection of currently available viability data from tests using fish cell lines. The database aims to be a comprehensive collection of available cell viability data associated with OECD TG 249. The data is collected through a standardized workflow that includes the assessment and rating of adherence to OECD TG 249. Thus, data is labeled as fully adherent, adherent with some deviations (e.g., different plate formats), or as relevant research data with a clear link to OECD TG 249. To reduce variability in the analysis of the data, concentration-response curves are created and visualized through a coherent and consistent method. Publicly available data is made available through the user interface of the database, which can be searched using the chemical name and a range of chemical identifiers, as well as filtered by experimental properties and OECD compliance level. Data can be exported as Excel or CSV file. Non-public data can be included but are only used internally to continually characterize the applicability domain of the assay. Each data point can be browsed individually through a detailed view. All data can further be explored without computational expertise through the accompanying FACTexplorer dashboard that provides an overview and summary statistics of the data contained at any point in time. This effort aims to strengthen the confidence in the utility of fish cell lines for chemical hazard assessment through showcasing the breadth of toxicity data and applications.

1.09.P-Tu125 A New Approach Methodology: Proteomic Profiling of Zebrafish Embryos for Manufactured Nanomaterial Toxicity Testing

Premkumari Kumarathasan[1], Jith Thomas[2], Erica Blais[3], Krishna Priya Syama[3], Nazila Nazemof[4], Zoran Minic[5], Yingxi Li[5], Abdullah Khraibah[5], Sanjeena Subedi[6], Jan Mennigen[7], Nipu Niepukolie[7] and Kessen Patten[8] (1)Environmental Health Science and Research Bureau, HECSB, Health Canada, Ottawa, ON, Interdisciplinary School of Health Sciences, Faculty of Health Sciences, University of Ottawa, Ottawa, ON, (2)Regulatory Toxicology Research Division, Health Product and Food Branch, Health Canada, Ottawa, ON, (3)Environmental Health Science and Research Bureau, HECSB, Health Canada, Ottawa, ON,

(4)Interdisciplinary School of Health Sciences, Faculty of Health Sciences, University of Ottawa, Ottawa, ON, (5)John L Holmes Mass Spectrometry Facility, University of Ottawa, Ottawa, ON, (6)School of Mathematics and Statistics, Carleton University, Ottawa, ON, (7)Department of Biology, University of Ottawa, Ottawa, ON, (8)INRS, Centre Armand-Frappier Santé Biotechnologie, Laval, QC

Recently, proteomics is being sought after for mechanistic information in chemical toxicology. Expression and affinity proteomics (e.g., interaction) are two approaches used very much in unravelling toxicity mechanisms. We examined molecular-level changes in Zebrafish embryos exposed to chemicals (Nanomaterials -NM) using a mass spectrometry-based proteomic analysis method to refine the utility of this alternative in vivo NM toxicity testing platform. Application of NMs in electronics, consumer products (e.g., cosmetics, food-additive/packaging) and biomedicine is expanding due to their attractive modifiable physicochemical properties. Surge in production/use of NMs in recent years also cause health concerns due to exposure potential requiring toxicity testing for risk analysis. Thus, Zebrafish embryos (chorionated) were exposed to well-characterized NMs (nanoSiO2, TiO2, ZnO) in E3 medium (dose:0-100 µg/mL;24 h-4 dpf). Chorionated, de-chorionated embryos were also exposed to tris(2-butoxyethyl)phosphate to examine impact of chorion on exposure-related effects. Phenotypic changes were assessed. Zebrafish embryo proteomic changes were analyzed using LC-Orbitrap MS/MS method, post-lysis, clarification, reduction/alkylation and enzymatic-digestion. Chorionated and de-chorionated embryos exhibited protein-level differences and differences in reproducibility these effects. NM-specific effects were seen in morphology, survival, hatching rates for nanoZnO exposure. Decreased locomotion was noticed for nanoZnO, with trends for nanoSiO2. NM type-, dose-, developmental stage-specific protein expressions demonstrated sensitivity, specificity of analysis. Enriched pathways included protein processing, mitophagy, metabolism, cellular senescence providing insight into toxicity mechanisms. Our findings suggest that the chorionated Zebrafish embryo model in combination with proteomics is promising for NM toxicity testing and warrants further exploration.

1.09.P-Tu126 Natural and Synthetic Phenolic Antioxidants – How Stability and Reactivity Influence In Vitro Toxicity

Bernadette Mederer[1], Luise Henneberger[1], Julia Huchthausen[1], Liana Brauer[1], Satoshi Endo[2] and Beate Escher[1] (1)Helmholtz Centre for Environmental Research (UFZ), (2)National Institute for Environmental Studies (NIES)

Antioxidants (AOs) are applied in preservation of food, personal care products or plastic material to scavenge reactive oxygen species (ROS). AOs can be categorized into natural antioxidants (NAOs) and synthetic phenolic antioxidants (SPAs). SPAs are frequently found in human and environmental samples. Despite high production volumes health hazard data are scarce. Cell-based in vitro bioassays offer an animal-free alternative for reliable high-throughput testing and can capture oxidative stress response (OSR) and mitochondrial membrane potential (MMP) disruption. AOs are difficult to test due to instability in bioassay medium, high reactivity and potentially even pro-oxidant behavior. We demonstrate how abiotic instability in medium, reactivity in three different AO capacity tests and toxicity response, namely cytotoxicity, OSR and MMP disruption, are interconnected. Thirteen out of 28 AOs, most of them NAOs, including Gallic acid (GA) and Pyrogallol, were unstable in medium. Comparing AO capacity, the oxygen radical absorbance capacity assay with Pyrogallol-Red (ORAC-PGR) and 2,2-Diphenyl-1-picrylhydrazyl (DPPH) scavenging assay were shown to be selective for unstable AOs. Enhanced cytotoxicity was typically observed for unstable AOs (e.g. Pyrogallol and GA), The majority of SPAs was stable and only exerted baseline toxicity (e.g., 4-tert

Octylphenol (4tOP) and Butylated hydroxyanisole (BHA)). Regarding OSR, tert-Butyl hydroquinone (tBHQ) was the most potent, while the majority of AOs showed only moderate effects. In contrast, SPAs without activity in OSR exerted MMP disruption (e.g. 4tOP and BHA). Addition of catalase to bioassay medium helped to identify if H2O2 was formed extracellularly by AOs. OSR was reduced for GA and Pyrogallol and cytotoxicity was removed after catalase treatment. OSR of other AOs like tBHQ was not changed by catalase. Intracellular ROS were visualized with a 2′,7′-Dichlorodihydrofluorescein-diacetate (DCFDA) staining. DCFDA revealed that intracellular ROS likely drive cytotoxicity and OSR for GA and Pyrogallol. In summary, the context-dependent interplay between antioxidant and pro-oxidant behavior poses a major challenge for the risk assessment of antioxidants. Unstable AOs can be identified with the ORAC-PGR and DPPH scavenging assay replacing time-intensive medium stability testing. Addition of catalase to the OSR assay and DCFDA staining help to identify pro-oxidant behavior, particularly relevant for NAOs.

1.09.P-Tu127 An Improved QSAR for Predicting Atmospheric Oxidation Kinetics of Organic Chemicals

Trevor N. Brown[1], Alessandro Sangion[1] and Jon A. Arnot[1] (1)ARC Arnot Research & Consulting

There are several major oxidants present in the atmosphere, the most important of which are hydroxyl radical (OH) and ozone (O3). The reaction between an organic molecule and an oxidant is a bimolecular reaction resulting in a bimolecular rate constant. However, most chemical fate and exposure models assume first order kinetics, so the bimolecular rate constant is multiplied by an assumed steady-state concentration of the oxidant to obtain a pseudo-first order rate constant. In this work Quantitative Structure Activity Relationships (QSARs) are calibrated for the bimolecular reactions rates of OH and O3 (kOH and KO3), and then to combined into a pseudo-first order atmospheric oxidation half-life. In addition, QSARs for the temperature dependence of the rate constants (BOH and BO3) have also been developed. QSAR development was undertaken by applying the IFSQSAR algorithm which has previously been applied to chemical partitioning and reactivity properties. IFSQSAR adheres to all OECD guidance on best practices for QSAR development, including internal and external validation, and quantification of the Applicability Domain (AD). The predictive power of the QSARs is good with an r2 and RMSE vs. external validation datasets of about 0.8 and 0.5 for log kOH, and 0.6 and 0.8 for log kO3. The predictive power is comparable or better than two other QSARs for atmospheric oxidation; Aopwin and OPERA. The new QSARs include AD information and an external validation which are lacking for Aopwin. They include both kOH and kO3, in contrast to OPERA which only includes kOH. They also include temperature dependence, which is not included in Aopwin or OPERA. QSARs are publicly available as a part of the EAS-E Suite online platform (www.eas-e-suite.com).

1.09.P-Tu128 Non-Invasive Detection of Low-Dose Radiation Exposure via Biofluid Omics Profiling

Erico Oliveira Pereira[1], Spencer Hang[1], Theresa Warriner[1], Quinn Eng[1], Kirk Atkinson[1] and Denina Simmons[1] (1)Ontario Tech University

Nuclear power has increasingly been suggested as a complementary solution in the pursuit of low-carbon energy sources to mitigate carbon emissions and meet global energy needs. Among the new nuclear-based technologies, small modular reactors (SMRs) are part of a special class of nuclear fission reactors. They are designed to be pre-made and transported for installation close to industrial facilities, as well as in remote areas,

such as lakes and the ocean. Consequently, low-dose radiation exposure is likely to occur in a range of species, including fish and humans. In our study, we aimed to establish alternative, non-invasive approaches to understanding the impacts of potential accidents associated with this new type of technology. For the fish component of the study, we exposed fathead minnows to low and high doses of ionizing (gamma) radiation for 7 days and 30 minutes, respectively. For the 7-day exposure, fish were exposed to an accumulated dose of approximately 0.05 Gy using coin-sized Cesium-137 sources. The higher dose exposure consisted of 0.77 Gy delivered over 30 minutes using a gamma irradiator system. Fish mucus samples were collected with paper tissues and analyzed for protein and metabolite biomarkers using untargeted mass spectrometry (MS)-based analysis. We also intend to collect human saliva from radiation workers (potential exposure group), administrative workers (negative control) and patients undergoing radiation-based diagnostic procedures (positive control). The saliva samples will be processed, and quantification of proteins and metabolites will be performed using the same MS-based approaches as for fish mucus. Bioinformatics tools are being used for the identification of biomarkers of exposure as well as for understanding impacts on specific pathways. We predict that responsive biomarkers will be associated with both DNA damage and oxidative stress responses. Given the potential of an increase in low-dose radiation exposure for both wildlife and humans, the identification of biomarkers of exposure could strengthen environmental monitoring efforts, as well as improve routine health monitoring and screening programs for nuclear sector workers.

Innovative Approaches for Difficult-to-Test Substances and Unknown or Variable Composition, Complex Reaction Products or Biological Materials

1.10.T-01 Addressing Chronic Aquatic Toxicity Test Requirements for Difficult To Test Surfactants

Rhiannon Smith[1], Rebecca Brown[1] and Erin Maloney[2] (1)wca environment Ltd., (2)Shell Global Solutions International BV

ERASM (Environment and Health – Risk Assessment and Management) commissioned a project to gather and synthesize data on properties which make surfactants difficult to test in chronic aquatic toxicity tests and solutions to optimise test performance. Data were collected through a search of published literature, including the Organisation for Economic Cooperation and Development (OECD) Test Guidelines and Guidance Document 23. Questionnaires were also completed by contract research organisations (CROs) and industry representatives on their experiences with difficult to test surfactants.

Many surfactants require chronic aquatic toxicity testing for regulatory purposes, but are difficult to test due to their surface activity. Many are also UVCBs (substances of Unknown or Variable composition, Complex reaction products or of Biological Origin), for which specific adaptations are necessary. Other key challenges include: poor water solubility, adsorption, rapid degradation, ionisation across the environmental pH range, volatility, and/or high background contamination. These challenges can mean ecotoxicity data may not meet reliability criteria or are difficult to interpret for regulatory purposes.

Adaptations for testing surfactants were considered based on: optimising solubility and dosing methods, modifications to the test design, adaptations based on the analytical method and reporting of results, and whether alternative ecotoxicology tests might be appropriate. Our findings show direct addition to be the most common dosing method, and most CROs avoided emulsions, solvents and generator systems. Potential

modifications were identified to avoid formation of surface films and aggregation of particles, including changes to test vessels, test media and feeding regimes. We also considered alternative test methods to generate data to meet regulatory information requirements and waivers to justify that standard aquatic toxicity tests expected for regulatory information requirements are not feasible.
This review collects examples of potential solutions to challenges for chronic aquatic toxicity testing of difficult to test surfactants, in order to understand the feasibility, applicability and regulatory acceptability for future testing. The review identifies gaps in the available guidance and areas where challenges remain with testing surfactants. It also notes where potential solutions from guidance are not adopted.

1.10.T-02 Expanding Chemical Space for Accurate High-Throughput Aquatic Toxicity Testing via Passive Dosing

Heather Brown[1], Alex Kasparek[2], Kevin Flynn[2] and Daniel Villeneuve[2] (1)U.S. Environmental Protection Agency (US EPA), (2)U.S. Environmental Protection Agency (US EPA)

To accelerate the generation of relevant aquatic toxicity data significant effort has been made to develop high-throughput aquatic toxicity tests, generally via the use of semi-automated methods in multi-well plate formats. In these formats, physiochemical properties of tested chemicals such as aqueous solubility and hydrophobic partitioning can cause significant deviation in actual exposure concentration from nominal dose. This can lead to inaccurate points of departure for use in hazard assessment that may underestimate the toxicity of the test substance. Passive dosing is a previously reported method of thermodynamic equilibrium-driven partitioning of hydrophobic chemicals. Generally, silicone is allowed to equilibrate with high concentration chemical, is subsequently washed and allowed to equilibrate with aqueous media. The dynamic equilibrium between aqueous media and pre-loaded silicone enables consistent concentration of chemical throughout a test.

To the best of our knowledge, passive dosing has not been applied to plastic multi-well plates for use in low-volume, high-throughput methods. As proof of concept, we passively dosed 96-well polypropylene plates with the relatively high log Kow p,p'-dichlorodiphenyl dichloroethylene (p,p-DDE; DTXSID9020374; log Kow: 6.67) and allowed aqueous test media to equilibrate. Using these data, calculated indirect partition coefficient (log K[methanol/water]) for p,p-DDE in our test system was consistent with previous data generated for p,p-DDE using a silicone elastomer (6.66 ± 0.06 vs 6.62 ± 0.03), indicating a similar partitioning mechanism for chemical from plastic well walls to aqueous media as is observed for silicone elastomers. Additionally, individual wells dosed at 1.7x concentration spacing show a quick aqueous equilibration period followed by relatively stable, predictable concentrations for up to 75 hours.

As has been noted by others, calculated indirect partition coefficient (log K[methanol/water]) scales linearly with log Kow. We expect a similar correlation in the 96-well plate format and are actively pursuing its use with other high log Kow chemicals with both ionic and non-ionic characteristics for accurate high-throughput aquatic toxicity testing. We expect this method to enable rapid, accurate derivation of points of departure for use in hazard assessment of chemicals at a concentration that is on the edge of aqueous solubility.

Disclaimer/Disclosure: This abstract does not constitute or reflect U.S. Environmental Protection Agency policy.

1.10.T-03 PULSE: A Pilot UVCB Library for Screening and Evaluation

Julie Krzykwa[1], Sandrine Deglin[1] and HESI Global UVCB Committee Tier 0 Database Working Group[1] (1)HESI Global

Substances of unknown or variable composition, complex reaction products, and biological materials (UVCBs) represent a significant portion of registered chemicals globally and pose challenges for risk evaluation. To address these issues, the UVCB committee of the Health and Environmental Sciences Institute (HESI Global) has developed a tiered, exposure-based framework to support UVCB prioritization. The initial tier (Tier 0) emphasizes basic characterization to identify potential exposure concerns, but depends on fundamental compositional, exposure, and other data that are often sparse or inconsistently reported in public sources and databases.

To help address this problem, the committee developed PULSE, a Pilot UVCB Library for Screening and Evaluation. PULSE was designed to evaluate the feasibility of collating publicly available Tier 0 information into a usable database for UVCB screening and prioritization. The pilot includes 109 UVCBs selected to cover a range of chemistries, uses, and regulatory relevance. Data were collected from public databases, regulatory assessments and dossiers, literature, supplier/manufacturer information, and expert judgment when empirical data were unavailable. The database includes identifiers, structural descriptors, identified constituents, whole-substance ecotoxicity data, process data, physicochemical properties, fate information, and use and registration data. Original information sources are retained so users can assess their confidence and the data limitations for their own use case.

This pilot demonstrated that a UVCB-specific database is feasible and useful, but also highlighted data gaps and the effort required for manual curation. Identification and use information were readily available, whereas whole-substance ecotoxicity, constituent, fate, physicochemical, and process data were often limited, incomplete, or estimated. These gaps reflect UVCB complexity and the fact that most public repositories were not designed for these substances. PULSE can support prioritization, read-across, complexity assessment, and data gap identification; however, future expansion will require partner buy-in and the development of more efficient update processes.

Disclaimer/Disclosure: The views expressed in this presentation are those of the author(s) and do not necessarily represent the views or the policies of the committee members' respective institutions.

1.10.T-04 Applying the "2 out of 3" Defined Approach (OECD 497) To Assess Skin Sensitization Potential of UVCBs Using the GARD®skin and EpiSensA Assays

Megan Solan[1], Hesbon Nyambego[1], Per Alftrén[2], Johan Andersson[2] and Tim Lindberg[2] (1)ExxonMobil Biomedical Sciences, Inc., (2)Senzagen AB

The skin sensitization adverse outcome pathway (AOP) published by the OECD in 2012 defined the key events (KEs) leading to allergic contact dermatitis. The AOP enabled the development of targeted non-animal methods focused on the first three KEs of the AOP, including the OECD guidelines 442C (KE1), 442D (KE2), and 442E (KE3). While none are standalone replacements, the methods can be combined under defined approaches (DAs) within OECD 497 or used in weight of evidence (WoE)-based evaluation. Here we demonstrate how the assays

included in the latest revision of OECD 497 enable a 2o3 DA for UVCBs. GARDskin (OECD 442E) is a genomic, machine learning-based assay targeting KE3 (dendritic cell activation) of the AOP. Multiple peer-reviewed studies have demonstrated the method's applicability to challenging test materials like hydrophobic substances (Log P > 3.5) and UVCBs attributable to its broad solvent compatibility. EpiSensA (OECD 442D) is an in vitro skin sensitization assay using a Reconstructed Human Epidermis (RhE) model targeting KE2 (keratinocyte activation). Direct test material application to the RhE surface makes the EpiSensA suitable for evaluating challenging materials. Three UVCBs were assessed for sensitization potential: a phthalate ester (PE; Log P=8.12), a polyalphaolefin (PAO; Log P=10.64) and an adipate ester (AE; LogP=10.64). for the GARDskin assay, the test materials were solubilized in ethanol, hexane, and dimethyl sulfoxide, respectively. For EpiSensA, all test materials were found to be soluble in acetone: olive oil (4:1). Hazard predictions for the UVCBs were made following acceptance of the test criteria and viability measurements. None of the test materials reduced viability or exceeded defined target gene thresholds in the EpiSensA assay. In the GARDSkin assay, the mean DVs were -0.272, -1.79, and -1.33 for PE, PAO, and AE, respectively. Taken together under the 2o3 DA, all three test materials are non-sensitizers. GARDskin and EpiSensA assays have broad chemistry applicability, making them suitable for challenging substances. For potency categorization, an Integrated Testing Strategy (ITS) including OECD 442C assay must be used, however, these assays remain problematic for many UVCBs substances. Still, the combined GARDskin and EpiSensA assays are particularly well suited for UVCB hazard evaluation and may support potency categorization with additional data in a WoE approach.

Disclaimer/Disclosure: Funding for this work was provided by ExxonMobil Product Solutions

1.10.T-05 Protein Corona Evaluation on Polystyrene Nanoplastics Following Gastric Biotransformation

Aqsa Sadiq[1], Jose Luis Fonseca[1], Sara Bogialli[1], Giorgio Arrigoni[2] and Fazel Abdolahpur Monikh[1]
(1)Department of Chemical Sciences, University of Padova, Padova, Italy, (2)Department of Biomedical Sciences, University of Padova, Padova, Italy

Nanoplastics entering the human body encounter multiple biological environments that can alter their physicochemical properties and biological identity. While protein corona formation in blood has been extensively investigated, the influence of prior gastric biotransformation on subsequent protein corona development remains poorly understood.

This study aims to evaluate how gastric media affects the biological identity of polystyrene nanoplastics and their interactions with proteins in human serum. Pristine and oxidized polystyrene nanoplastics with different particle sizes and surface charges were exposed to simulated gastric fluid (SGF) containing pepsin under physiologically relevant conditions. Following gastric incubation, pre-treated plastics were recovered and incubated in human serum to investigate protein corona formation. Changes in particle size distribution, surface charge, morphology and surface chemistry were characterized by dynamic light scattering, zeta potential measurements, transmission electron microscopy, and Fourier-transform infrared spectroscopy. Protein corona samples were collected for subsequent proteomic analysis to identify plasma proteins associated with nanoplastics of different sizes, surface charges, and oxidation states following gastric biotransformation. Preliminary results indicate that gastric biotransformation alters the physicochemical properties of nanoplastics, including hydrodynamic size, surface charge, and aggregation behavior, thereby influencing their subsequent interactions with the human serum proteins. Ongoing proteomic analyses are expected to determine how

particle size, surface charge, and oxidative aging influence protein corona composition following gastric biotransformation.
These findings provide insight into the dynamic evolution of nanoplastics as they transition from the gastric environment to systemic circulation. This study establishes a framework for understanding how gastric biotransformation may influence subsequent protein corona formation and ultimately affect nanoplastic fate, biological interactions, and potential health risks associated with human exposure.

1.10.T-06 Continuously Operating Wildfire Smoke Simulator (COWSS): A New Method To Generate Wildland Urban Interface Smoke

Laura Van Winkle[1], Morgan Domanico[2], Chris Wallis[3] and Anthony Wexler[4] (1)Center for Health and the Environment & School of Veterinary Medicine, University of California Davis, (2)Center for Health and the Environment, UC Davis, (3)Air Quality Research Center, University of California Davis, (4)Air Quality Research Center and College of Engineering, UC Davis

Wildland Urban Interface (WUI) fires are increasing in prevalence. Approaches for sampling WUI fire emissions in real time are limited by accessibility, reproducibility, predictability, and a lack of characterization of both gas and particle emissions in smoldering and burning phases. Defining which fuel materials create the greatest toxicity can guide building material regulation. As a first step toward addressing this need, we have developed a novel device, COWSS (Continuously Operated Wildfire Smoke Simulator), to produce surrogate WUI fire smoke. COWSS facilitates reproduceable, long term smoke exposures in smoldering and flaming conditions using materials typical of the composition, size and shape found in the WUI. Here, emissions from a variety of building construction materials were burned using the COWSS system. The resulting emissions were characterized by PM size and concentration, and were introduced into 200mL of cell culture media using an impinger. The building construction materials consisted of realistic mixtures of fir wood, composite wood consisting of plain and latex coated OSB and MDF, and synthetics consisting of pink urethane foam insulation board, PVC pipe, carpet, composite roofing shingles, and furniture foam composites. Each burn period lasted 90 min. Mix 1 was 2 parts composite woods: 1 part synthetic. Mix 2 was 1 part composite: 4 synthetic. To test toxicity, confluent human A549 alveolar epithelial cells were exposed to these mixes at dilutions of 100%, 50%, 10%, and 5%. Cytotoxicity was assessed at 24 hrs by fluorescent direct cell counting of dead, membrane permeable, and total cells compared to a media-only control and a hydrogen peroxide positive control for cytotoxicity. In a direct comparison of the two WUI mixes only WUI Mix 2 significantly increased the percentage of dead cells detected in a dose dependent manner. It is interesting to note that, at the same levels of dilution, WUI Mix 2 was more cytotoxic than WUI Mix 1, even though (a) both contained the same source fuels just in different ratios and (b) WUI Mix 1 had more PM total content. We conclude that the burning synthetic sources in Mix 2 are more toxic to lung cells.

Disclaimer/Disclosure: Supported by P30 ES023513

Innovative Approaches for Difficult-to-Test Substances and Unknown or Variable Composition, Complex Reaction Products or Biological Materials

1.10.P-We302 Seasonal Pattern of Steroidogenic Disruption by PM2.5 Extracts From

Seoul in H295R Cells

Eunhye Kim[1], Hyejin Shin[1], Taeyeon Kim[1], Seung-Muk Yi[1] and Kyungho Choi[1] (1)Seoul National University

Fine particulate matter with an aerodynamic diameter of ≤2.5 μm (PM2.5) is a complex air pollutant associated with various adverse health outcomes. While PM2.5 toxicity has been widely investigated, its potential to disrupt endocrine function, particularly steroidogenic pathways, remains insufficiently understood.
The current study evaluated whether PM2.5 organic extracts collected in Seoul alter steroid hormone production in H295R cells and whether these effects are associated with differences in organic chemical composition. PM2.5 samples were collected during winter (December 2024–February 2025) and summer (July 2025) and extracted using methanol/dichloromethane (1:1, v/v). Human adrenocortical carcinoma cells (H295R) were exposed to PM2.5 extracts at equivalent mass-based concentrations of 0, 7.5, 15, and 30 μg/mL for 48 h. Organic chemical profiles were characterized by GC/MS.
Exposure to the winter PM2.5 extracts induced a concentration-dependent increase in E2 and a decrease in T, resulting in a significant increase in the E2/T ratio. In contrast, summer PM2.5 extracts showed limited hormonal effects. Consistent with these hormone responses, the winter PM2.5 extracts increased the expression of CYP19A1, which encodes aromatase, and decreased CYP17A1 expression, suggesting altered steroidogenic enzyme regulation and enhanced conversion of T to E2. GC/MS analysis showed that winter PM2.5 was characterized by PAHs, n-alkanes, sugars, and glycerides, suggesting contributions from heating and biomass combustion sources, whereas summer PM2.5 contained relatively higher levels of benzenecarboxylic acids and alkanoic acids, reflecting secondary organic aerosol formation and other seasonal sources.
Altogether, PM2.5 organic extracts from Seoul can disrupt steroidogenesis in H295R cells, with stronger effects observed for winter samples. These findings demonstrate that the endocrine-disrupting effects of PM2.5 depend not only on particle mass but also on season-specific chemical composition, highlighting the importance of composition-based toxicity assessment in PM2.5 health risk evaluation.

1.10.P-We303 Characterizing the Chemical and Toxicological Impacts of Environmental Surface Coatings Using Human Cell Lines To Determine Potential Health Impacts

Ivana Gulati[1], Blake Hunnie[1], Amanda Ferrer[1], Tara Kahan[1] and Markus Brinkmann[1] (1)University of Saskatchewan

Urban surfaces are continuously exposed to airborne pollutants, leading to the accumulation of a complex mixture of chemical and biological species over time, referred to as environmental surface coatings (ESCs) or “urban grime". These coatings can be washed away during rainfall or remobilized to air, contributing to the chemical load of urban runoff and secondary air pollution, respectively. Several highly toxic organic pollutants, such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and polybrominated diphenyl ethers (PBDEs), have been found in ESC extracts, raising concerns about increased concentrations of these pollutants in urban environments. While researchers have begun to uncover the chemical behaviour of ESCs, there is a major gap in our understanding of their toxicological impact. To date, there is very limited information on how ESCs affect living systems, either in animal (in vivo) or cellular (in vitro) models. This study aims to evaluate the toxicity of urban grime by conducting fish embryo toxicity assays using Danio rerio (zebrafish) and cytotoxicity assays across multiple human cell lines, with a particular focus on respiratory cell lines in addition to exploring underlying mechanisms of action, using cells that represent key organs and toxicity pathways of concern, most notably reactive oxygen species (ROS) generation. To complement in vivo

and in vitro assays, non-target chemical analysis will be performed using gas chromatography-mass spectrometry (GC-MS) techniques to identify chemical contributors to ESC toxicity. Thus far, preliminary results have shown that ESCs are not significantly cytotoxic to adenocarcinomic human epithelial (A549) cells but are able to cause ROS induction in a dose-dependent fashion, with high concentrations causing a 3-fold increase in ROS generation compared to controls. Overall, the aim of this research is to integrate the toxicological and chemical results to predict its relative contribution to overall ESC toxicity, understand the mechanisms of action behind the observed toxicity, and ultimately enhance risk assessment frameworks by providing a more comprehensive understanding of ESC toxicity.

1.10.P-We304 Biological Effects of Microcapsules 4 - Quantification of Chemical Load and Its Implications for Exposure Assessment

Yukiyo Okazaki[1], Soramu Komeyama[2] and Norihisa Tatarazako[2] (1)Ehime University, Osaka University, (2)Ehime University

Microcapsules are small particles that encapsulate chemicals within an inner core. Similar in size to microplastics, they enable controlled and sustained release of substances. These properties can be advantageous in aquatic ecotoxicity testing.
Microencapsulation stabilizes degradable chemicals and reduces volatility, allowing evaluation of substances otherwise difficult to test with standard waterborne methods. In addition, this approach shifts the exposure pathway of aquatic organisms from dermal or branchial absorption to oral intake, providing new insights into toxicokinetics and toxicity.

So far, we have investigated capsule synthesis methods and their reproducibility, measurement and estimation of capsule intake by fish (medaka), as well as methodologies for estimating exposure concentrations of encapsulated chemicals.
In this presentation, we introduce the behavior of chemicals during encapsulation of di(2-ethylhexyl) phthalate (DEHP) and present an extended study on toxicity testing using a microcapsule-based exposure system.

For quantification, microcapsules containing DEHP as a model compound were collected by filtration using a Teflon filter, followed by extraction and analysis by GC–MS. To identify at which stage of the synthesis process chemical loss occurred, various fractions—including tubes used before synthesis, tubes used for centrifugation, post-synthesis supernatant solutions, and washing solutions—were extracted with dichloromethane and analyzed in the same manner.
The results showed that a large portion of the chemical was adsorbed onto plastic tubes during the synthesis process, and that the measured concentrations changed depending on centrifugation time and storage duration.

As a method for toxicity testing using microcapsules, this approach aims to detect biological effects by exposing daphnids to encapsulated chemicals and analyzing gene expression responses after exposure.

Disclaimer/Disclosure: This work was supported by JSPS KAKENHI Grant Number JP25K03274 and a grant from the JCIA-LRI.

Microplastics, Chemicals and the Soil Beneath: Confronting the Growing Concern of Agricultural Plastic Pollution

1.12.P-Tu221 Evaluating Sub-Lethal Effects of LDPE and Biodegradable Mulching Alternatives Using Model Species Caenorhabditis elegans

Allisyn Miller[1], Bryan Harper[1], Stacey Harper[2] and Susanne Brander[3] (1)Oregon State University, (2)Oregon State Univeristy, (3)The Pew Charitable Trusts

For over 75 years, low-density polyethylene (LDPE) mulching films have been a staple of intensive agriculture, valued for weed suppression, soil moisture retention, and temperature regulation. However, decades of seasonal deployment and low recovery rates have left a measurable cost within soil ecosystems. Physical fragmentation through tillage, UV photodegradation, and precipitation breaks down these films into micro- and nanoplastics that have persisted in soils. Concentrations in high-intensity farmland are well into the hundreds to thousands of particles per kilogram of soil, with well-documented transport into nearby bodies of water. Within the soil profile, LDPE-derived microplastics have been associated with disruptions to edaphic invertebrate communities that contribute to nitrogen cycling, inducing oxidative stress responses, and reproductive impairment from particle ingestion. Despite growing evidence of these impacts, direct comparisons between LDPE-derived particles and alternative mulching materials remain limited.

To inform the transition away from LDPE mulch towards more sustainable materials, this study presents a comparative dose-response of particle-associated effects derived from LDPE alongside three alternative mulching materials: a certified biodegradable starch-based film (BIO360), wool pellets, and cellulose-based paper mulch. Particles were cryomilled to an average size of approximately 3 µm, then mixed in a solution of water and humic acid pre-filtered through a 0.2 µm filter and finally passed through 20 µm mesh filters. Caenorhabditis elegans at the L3 stage were exposed across concentrations of 0, 0.1, 10, and 100 particles/mL over a 24-hour acute exposure and a 96-hour reproductive bioassay. Sub-lethal endpoints assessed included juvenile reproductive output, and survival at 24 hours. Results suggest that LDPE may cause significant concentration-dependent reproductive disruption in C. elegans, with juvenile output declining from 0.1 particles/mL and up. BIO360, wool, and paper mulch particles showed no significant reproductive change, suggesting LDPE-specific toxicity rather than a general particle effect. No evidence of acute lethality was indicated at 24 hours across any treatment. These findings aim to connect critical conversations between agriplastic research and actionable policy guidance supporting sustainable mulch transitions.

1.12.P-Tu222 Tracking Plastic Fate in Agricultural Soils: Microbial Community Dynamics and Biodegradation

Yuki Floyd[1] and Arturo Keller[2] (1)University of California Santa Barbara (UC Santa Barbara), (2)UC Santa Barbara

Plastic mulch films are widely used for their benefits in increasing crop yield, covering millions of acres worldwide. Due to their thin and pliable nature, regularly replacing films leads to the accumulation of plastic debris in soils, raising concerns for soil ecosystem health and long-term viability of food systems. Plastic debris in soils can serve as vectors for pathogens, leach harmful chemicals, generate micro- and nano- particles and can disrupt natural microbial communities that are essential in sustaining healthy soils. In order to mitigate

these concerns, biodegradable plastics have been offered as an alternative to conventional plastic film, although their potential risks and benefits vary across environments and are not well understood. In order to maximize benefits while limiting concerns around plastic contamination, better understanding of plastic degradation mechanisms is needed to optimize conditions for biodegradation of plastics in agricultural soils and fill knowledge gaps associated with the long-term implications of both biodegradable and conventional plastics on soil health and sustainability.
This research aims to better understand the relationship between soil microbial ecology and plastic biodegradation by studying changes in microbial community composition and degradation of biodegradable and conventional plastic mulches over time. This will help inform decision making for alternative plastic use practices, strategies for mitigation of existing plastic contamination in the environment, and contribute to knowledge of bioremediation strategies to sustain soil ecosystem health.

1.12.P-Tu223 Microplastic Exposure in Hydroponic Zea mays: Evaluating Polyamine Oxidase as a Transcriptional Stress Indicator

Elizabeth Matsuura[1], Ellee Cook[1] and Maren LaLiberty[1] (1)Shattuck-St. Mary's School

Microplastics (plastic particles smaller than 5 mm) have become ubiquitous environmental contaminants, accumulating in soil and water and entering the tissues of plants, including agricultural crops. Prior work indicates that microplastics can alter root physiology, photosynthesis, and gene expression in maize and other species, yet the molecular stress responses they trigger remain poorly characterized. This study asks whether microplastic exposure induces a measurable stress response in corn (Zea mays), using polyamine oxidase (PAO) as a candidate biomarker. PAO is an enzyme that contributes to hydrogen peroxide production during plant wound healing, and its transcription increases in mechanically damaged corn (Angelini 2008), making it a plausible indicator of microplastic-induced stress. We hypothesized that corn grown in water containing microplastics would exhibit higher PAO expression than corn grown in microplastic-free water. To test this, Zea mays seedlings were germinated and grown hydroponically in growth medium with or without microplastic particles. After two weeks, RNA was extracted from each group, reverse transcribed to cDNA, amplified by PCR, and visualized by gel electrophoresis, with actin serving as a reference gene. Initial results showed no clear difference in PAO cDNA between treatments; however, inconsistent actin reference bands rendered these results inconclusive and pointed to a need to refine the hydroponic protocol and standardize the loading control. Ongoing work addresses these limitations by adopting quantitative PCR (qPCR) for precise transcript measurement and by comparing nanoplastics against microplastics and an untreated control. This comparison is motivated by evidence that nanoplastics, unlike microplastics that tend to aggregate on root surfaces, can penetrate plant tissue more readily and may therefore provoke a stronger molecular response. By pairing a transcriptional stress marker with a refined, quantitative method and a particle-size comparison, this study aims to clarify how plastic pollution affects crop plants at the molecular level and to evaluate PAO expression as a tool for detecting that stress.

1.12.P-Tu224 Assessing the Effects of Tire Wear Particles and Road Salt on Terrestrial Isopods

Christopher Musgrave[1] and Ryan Prosser[1] (1)University of Guelph

Roadside environments are exposed to multiple anthropogenic contaminants, including tire wear particles (TWPs) and road salts, yet their combined effects on terrestrial detritivores remain poorly understood. This study investigates the impacts of individual and combined exposure to TWPs and sodium chloride (NaCl) on three terrestrial isopod species, Porcellio laevis, Porcellio scaber, and Porcellionides pruinosus. Previous work from our laboratory demonstrated that these species readily consume weathered polyethylene fragments and tire particles, generating smaller microplastic particles with limited adverse effects following short-term exposure. However, environmental stressors rarely occur in isolation, and interactions among contaminants may alter organismal responses.

Isopods were exposed for 28 days to TWPs incorporated into food, NaCl-amended artificial soil, or a combined treatment consisting of both contaminants. Exposure concentrations reflected environmentally relevant and elevated roadside conditions. Endpoints included survival and growth, allowing for comparison of species-specific responses to contaminant exposure. In treatments containing TWPs, particle characterization was conducted before and after exposure to evaluate changes in particle size associated with ingestion. By examining both single- and multi-stressor exposures, this study provides insight into how common roadside contaminants may influence soil detritivores and highlights the importance of considering contaminant mixtures in terrestrial ecological risk assessment.

1.12.P-Tu225 Microplastic Alternatives in Agriculture – Research and Progress

Ifeoluwa Bamgbose[1] (1)Gradient

The prevalence of microplastics in agricultural soils highlights the need to critically evaluate seed-coating technologies, particularly those marketed as microplastic-free. Globally, agriculture contributes approximately four percent of plastic demand, driven largely by mulch films, irrigation tubing, fertilizers, and seed coatings. In the European Economic Area, agricultural use of intentionally added microplastics is estimated at 10,000 tonnes annually, with treated seeds contributing approximately five percent of the microplastics released into the environment. Although seed coatings represent only about one percent of the global agricultural microplastic burden, they remain ecologically significant due to their direct placement in soil surrounding germinating seeds and developing root systems. Conventional seed coatings commonly incorporate synthetic polymers such as polyvinyl alcohol, polyvinyl acetate, polyurethane, and acrylic copolymers that can fragment into microplastics and potentially alter soil microbial communities, root growth, and water uptake. Additionally, these fragments may influence the dissipation of co-applied agrochemicals.

Emerging microplastic-free seed coatings are reported to utilize biodegradable, bio-sourced polymers, including starch and cellulose derivatives, chitosan, alginates, and plant oil-based materials; however, their environmental safety cannot be assumed. Significant gaps remain in our understanding of their chemical composition, potential toxicity of any formulation additives, biodegradation pathways, and environmental fate, as well as how these coatings interact with soil biota, influence nutrient cycling, and affect non-target organisms. Since claims of biodegradability and bio-sourced origin do not necessarily indicate ecological safety, greater formulation

transparency, along with a thorough assessment of biodegradation processes and potential toxicological effects, is important to determine whether these microplastic-free seed coatings truly offer a safer alternative for the environment.

1.12.P-Tu226 Impact of Microplastics on Bentonite Hydration in Landfill Barrier Systems

Joseph Acquah[1], Damien Callahan[2], Abdelmalek Bouazza[3], Abbas El-Zein[4] and Will P. Gates[1] (1)Institute for Frontier Materials, Deakin University, Melbourne, (2)School of Life and Environmental Sciences, Deakin University, Melbourne, (3)Department of Civil and Environmental Engineering, Monash University, Melbourne, (4)School of Civil Engineering, University of Sydney, Sydney

Sodium (Na) bentonite is the main functional component of geosynthetic clay liners (GCLs), which are a critical hydraulic barrier in landfill containment systems. In landfill environments, biological, chemical and physical processes cause plastic waste to fragment into microplastic (MP) particles and here is growing concern about MP migration through engineered barriers. While GCLs are designed to be an important secondary line of defence against leachate migration through geomembrane leaks, the impact of MPs as emerging contaminants on Na-bentonite hydration and hydraulic performance remains poorly understood. The influence of MPs on Na-bentonite water uptake capacity under free-swell conditions and fluid loss (ASTM D5891-02) under a 100 psi (690 kPa) hydraulic head were investigated using recycled high-density polyethylene (rHDPE) <600 µm, recycled polyethylene terephthalate (rPET) <600 µm, and 25-85 µm polypropylene (PP) spheres, with <75 µm sand used for direct comparison of 30% loading with MP, representing a worst-case scenario. Four conditions for water uptake tests were tested specifically on 30% rHDPE addition determined by gravimetric water content (GWC): (i) a bentonite-only control, (ii) MPs fully mixed with bentonite prior to the test, (iii) MPs placed as a distinct layer above the bentonite with no intermixing, and (iv) MPs placed below the bentonite with no intermixing; where ii-iv simulates environmental MP scenarios settling from leachate (above), presence within subgrade (below), or uniform intermixing within the barrier. Fluid loss tests were conducted at (5, 10, 20, and 30 weight %) MP loadings. The Na-bentonite had a free swell GWC of 534.9± 7.6%, while samples with intermixed rHDPE were reduced to 365.7± 7.8%, a 32% loss in water uptake expected from MP acting as diluents. Placement of rHDPE below the bentonite resulted in an increase in GWC to 375.3± 8.2%, whereas placement of above yielded 403.7± 12.6% GWC, suggesting less interference with water uptake and swelling. Fluid loss tests showed marginal increases (PP > rPET > rHDPE); all dosages remained <15 mL/2g, well below the industry specification for GCLs (<18 mL/2g). Under these conditions and environmentally relevant concentrations, MPs act as non-swelling diluents but are unlikely to significantly compromise the hydraulic performance of the Na-bentonite barrier, suggesting GCL systems should maintain effectiveness despite MP contamination.

Disclaimer/Disclosure: The authors acknowledge Australian Research Council's Discovery Projects scheme (DP220100218).

Microplastics, Chemicals and the Soil Beneath: Confronting the Growing Concern of Agricultural Plastic Pollution

1.12.V-01 Mycoremediation of Polyethylene Terephthalate Microplastics Using Pleurotus

ostreatus: Impacts on Soil Health and Crop Performance

Nyssa Kansal[1] (1)The Harker School

By 2018, the agricultural industry utilized more than 6 million cumulative tons of agroplastic globally. Polyethylene Terephthalate (PET) is one of the most widespread microplastic (MP) polymers found in agricultural soils. MPs modify physical and chemical properties of soil (pH, soil aggregation, bulk density, water holding capacity), damage plant photosynthesis and chlorophyll content, negatively impact plant growth and yield, and act as vectors for agrichemicals, heavy metals, and pathogens within soil. Pleurotus ostreatus (oyster mushroom) has the ability to produce enzymes called Mn-peroxidase and laccase that support the oxidation and degradation of PET. Although research regarding how MPs affect soil and plant health exists, no study investigates the potential of P. ostreatus to mitigate MPs while simultaneously analyzing soil and plant health.

We conducted a 15-week field experiment testing three treatments (control, PET, and P. ostreatus + PET) on tomato, bean, and pepper systems, with three replicates and two plants per pot, totaling 27 pots and 54 plants. Soil moisture, fertility, pH, plant growth, and yield were measured weekly; microbial abundance and MP characteristics were determined by soil microscopy performed at baseline and harvest. Two-way ANOVA showed a significant effect of treatment on total MP abundance ($p = 0.0039$). Across all crop systems, the P. ostreatus + PET treatments exhibited the lowest increase in MPs over time. The P. ostreatus + PET treatment also increased soil microbiota diversity, moisture retention, and fertility, with the pepper P. ostreatus + PET treatment outperforming all others. There were a total of 11 observed MP color changes, an indication of polymer alteration. 91% (10 out of 11) of the color changes occurred in the pepper P. ostreatus + PET treatment, suggesting fungal-mediated transformation and plastic degradation. Plant height, yield, and chlorophyll varied across crops with no consistent trend, indicating that PET presence did not significantly impact plant health in the concentrations and timescale tested in this experiment.

These findings highlight P. ostreatus as a scalable, nature-based approach to mitigating PET presence in agricultural soils, with the potential to be applied in sustainable farming and plastic remediation strategies.

Navigating the Nexus: Advancing Endocrine Disruptor Assessments Through Intersectoral Collaboration and Innovative Science

1.13.T-01 Development of an In Vitro to In Vivo Extrapolation Approach To Assess Endocrine Activity in Fish

Jaylen Sims[1], Jonathan Haselman[2] and Scott Lynn[2] (1)Oak Ridge Institute for Science and Education (ORISE), (2)U.S. Environmental Protection Agency (US EPA)

The U.S. EPA is exploring New Approach Methods, like in vitro-to-in vivo extrapolation (IVIVE), to increase the pace and reduce the cost and animal usage of endocrine disruption screening for hundreds of pesticide chemicals. Toxicokinetic (TK) models are a key component of mammalian IVIVE approaches, but similar approaches for fish are limited. The objective here is to leverage IVIVE approaches used in human health assessments as a model for predicting endocrine activity in fish. Chemicals with in vivo fecundity lowest observed effect concentrations (LOEC) in fish were collected as benchmark reference values. Endocrine-related

in vitro bioactivity points of departure (POD) from high-throughput assays (e.g. estrogen receptor [ER]) were collected for chemicals having corresponding in vivo fecundity LOECs. Empirical in vitro TK data (fraction unbound in blood [fUB] and intrinsic metabolic clearance [Clint]) were also collected for those same chemicals. Exposure and Safety Estimation Suite was then used to compile Quantitative Structure Activity Relationship (QSAR)-modeled fUB and whole-body biotransformation rates (kB), and to extrapolate empirical in vitro Clint to whole-body kB values for a comparison of empirical fUB and kB values to their QSAR-modeled counterparts. Lastly, reverse TK (rTK) modeling utilized in vitro PODs as free blood concentrations to evaluate the concordance between predicted exposure water concentrations and in vivo fecundity LOECs in fish. Both the empirically derived fUB and IVIVE (using empirical Clint) kB values exhibited positive and significant correlations to the QSAR-modeled values ($p<0.05$). The rTK-predicted exposure concentrations (using the most sensitive PODs) were significantly correlated to the in vivo fecundity LOECs (n=19, p=0.009, r2=0.30), and this relationship strengthened when constraining the dataset to chemicals with positive ER agonist scores (n=7, p=0.004, r2=0.80). The significant relationships between the empirical in vitro TK data and QSAR-modeled TK parameters indicate QSAR-modeled values are likely sufficient for TK model parameterization for this limited dataset. When constraining the dataset to chemicals with positive ER agonist scores, a strong relationship was observed between the rTK model-predicted exposure concentrations and empirical in vivo fecundity LOECs, showing promise as a viable tool for predicting in vivo fecundity effects in fish. This abstract does not necessarily reflect US EPA policy.

1.13.T-02 Using Case Study Chemicals To Evaluate New Approach Method Integration for Estrogen Receptor Activity Screening in Aquatic Vertebrates

Julie Krzykwa[1], Amy Marriott[2], Michelle Embry[1] and Natalie Burden[2] (1)HESI Global, (2)NC3Rs

New approach methods (NAMs) are increasingly proposed for endocrine activity screening in aquatic vertebrates, but practical guidance is still needed on how to interpret and weigh these data. The Health and Environmental Sciences Institute (HESI Global) and the UK National Centre for the 3Rs, with support from a diverse planning committee, convened a virtual workshop to evaluate how NAM data could be used to assess estrogen receptor agonism using anonymized chemical datasets inspired by real-world information. Participants worked in small groups to review prepared data packages that included physicochemical information, in silico predictions, existing mammalian data, in vitro assay results from human and aquatic vertebrate systems, and eleutheroembryo models, with endpoints relevant to estrogen receptor activity as well as broader endocrine and toxicity outcomes. In vivo fish data were provided at the end of the discussions for comparison. Discussions focused on how confidence changed as evidence was introduced and when data were sufficient to support prioritization and decisions about needs for additional testing.

Across groups, confidence was highest when estrogen-relevant evidence was concordant across multiple evidence streams. Early-stage physicochemical and in silico information was useful for identifying potential concerns and guiding next steps, but was generally not considered sufficient on its own to support confident activity determinations. Confidence increased when in vitro, pre-existing mammalian, or eleutheroembryo data provided similar activity assessments. Participants were more comfortable acting on consistent evidence for activity than concluding a lack of activity, especially when data gaps, out-of-domain predictions, uncertain species relevance, or incomplete endocrine pathway coverage limited confidence in the overall evidence package.

The workshop identified several areas where additional guidance is needed, including interpreting NAM outputs, weighting weak or discordant evidence, determining when negative results are sufficient, and connecting mechanistic activity data to species relevance and organism-level outcomes. Overall, the discussions showed that NAMs can support staged screening of estrogen activity, but confidence depends on problem formulation, concordance across evidence streams, and transparent criteria for determining when the data are sufficient.

1.13.T-03 Bridging In Vivo and In Vitro Evidence From New Approach Methodologies (NAMs): Comparing XETA and ToxCast Data To Identify Thyroid-Active Substances

David Du Pasquier[1], Barbara Duchesne[2], James Wheeler[3], Paula Garcia[4], Katherine Coady[5], Laurent Lagadic[6] and Gregory Lemkine[1] (1)Watchfrog S.A., (2)Watchfrog S.A, (3)Corteva Agriscience UK Limited., (4)Corteva Agriscience, (5)Bayer CropScience, (6)Bayer AG, Crop Science Division, Environmental Safety

The identification of thyroid-active chemicals remains a major challenge for hazard assessment. The thyroid system can be affected through various mechanisms, including hormone synthesis, metabolism, and receptor-mediated pathways. To improve mechanistic understanding, it is essential to establish the coherence between in vivo and in vitro New Approach Methodologies (NAMs) targeting the thyroid axis.
The Xenopus Eleutheroembryonic Thyroid Assay (XETA) is an OECD test guideline (OECD TG 248) for identifying thyroid active chemicals. The XETA uses fluorescent Xenopus laevis transgenic eleutheroembryos to identify activity of the thyroid axis and how it can be altered by chemicals. As it uses non-protected embryonic life-stages, according to the current EU legislation on the protection of experimental laboratory animals, the XETA is considered a NAM.
In the present work, we conducted XETAs with reference chemicals selected with existing knowledge on their specific mechanism of action in mammals to expand the dataset of reference chemicals that were used in the OECD validation of the test guideline. In total, 60 reference chemicals have now been tested in the XETA. These substances were selected to represent a broad range of mechanisms, including thyroid peroxidase inhibition, thyroid hormone synthesis disruption, altered deiodinase activity, and competitive binding to thyroid hormone transport proteins.
To further explore the mechanistic concordance between in vivo and in vitro NAMs, we have interrogated the CompTox Chemicals Dashboard containing relevant high- throughput bioactivity data (ToxCast andTox21 databases) to retrieve assay data for the same set of chemicals. We have then performed a comparative analysis to evaluate the level of agreement between the responses in the XETA and the high-throughput in vitro mechanistic signatures.
This combined analysis aims to (i) assess the reliability of the XETA in capturing thyroid-related mechanisms of action; (ii) identify consistencies and discrepancies with in vitro assay outcomes; and (iii) contribute to the integration of mechanistic data in a weight-of-evidence approach for endocrine disruptor identification. Ultimately, this work will help clarify how amphibian-based embryo assays and large-scale in vitro screening platforms can be used to support the implementation of NAMs and provide confidence in the assessment of thyroid-active substances within regulatory contexts.

Disclaimer/Disclosure: This work was financially supported by CropLife Europe.

1.13.T-04 From Activity to Adversity: A Case Study Advocating Fit-for-Purpose Higher-Tier Studies in Non-Target Organism Endocrine Disruption Assessment

Pria Mahabir[1] and Daniel Pickford[1] (1)Syngenta

According to WHO/IPCS (2002) an endocrine disruptor is an exogenous substance or mixture that alters function(s) of the endocrine system and consequently causes adverse health effects in an intact organism. The OECD 231 Amphibian Metamorphosis Assay (AMA) is the current gold standard for investigating thyroid-disrupting activity in non-target organisms. However, as a screening-level assay, the AMA is designed to detect endocrine activity, not adversity to the organism. Within existing regulatory paradigms, a positive AMA can trigger extensive higher-tier testing, even when biological significance is uncertain. We present a case study with a model acetyl-CoA carboxylase (ACCase) inhibitor herbicide, which produced a positive finding in the AMA according to the test guideline. The Larval Amphibian Toxicity Test (LATT), a relatively new higher-tier study with greater statistical power and a more appropriate exposure window and duration, was subsequently conducted on the same compound (US EPA, 2024). The LATT showed no thyroid-related effects, demonstrating that the AMA activity screening signal did not translate to adversity that may be relevant at population level. This outcome argues for a paradigm shift in how we approach endocrine disruptor assessment for non-target organisms. Rather than using the AMA – an in vivo study with significant animal use costs –as a screen for activity, we advocate for a greater use of new approach methods (NAMs) such as mechanistic screening tools (e.g., transcriptomics assays in zebrafish embryos or eleuthero embryonic assays XETA OECD 248/ FET4Thyroid) that identify activity followed up where necessary with fit-for-purpose higher-tier studies like the LATT as a more suitable definitive test for adversity. The LATT is statistically powered to detect developmental effects compared to endpoints available in the AMA, which are not mechanistically informative nor indicative of population relevant adversity. Conducting the appropriate study for the appropriate question is not only scientifically defensible but reduces animal use, accelerates decision making and addresses the endocrine disruptor identification criteria that require demonstration of population relevant adversity effects.

1.13.T-05 Tiered Assessment Scheme Linking NAMs to Adverse Outcomes To Support a Weight-of-Evidence-Based Identification of Thyroid Disruptors in Aquatic Vertebrates

Laurent Lagadic[1], Katherine Coady[2], Oliver Körner[3], Tara Miller[4], Valentin Mingo[5], Edward Salinas[1], Ursula Sauer[6], Christel Schopfer[7], Lennart Weltje[8] and James Wheeler[5] (1)Bayer AG Crop Science Research & Development, (2)Bayer Research & Development Services LLC, (3)ADAMA Agriculture Germany, (4)International Copper Association (ICA), (5)Corteva Agriscience UK Limited., (6)Scientific Consultancy – Animal Welfare, Neubiberg, (7)BASF Corporation, (8)BASF SE

According to the World Health Organisation and European Commission definitions, substances shall be considered as endocrine disruptors if they show adverse effects, have endocrine activity and the adverse effects are a consequence of the endocrine mode-of-action (using a weight-of-evidence approach based on biological plausibility), unless the adverse effects are not relevant to humans or non-target organisms at the population level. To date, there is no decision logic on how to establish endocrine disruption via the thyroid modality in non-mammalian vertebrates. We present an evidence-based decision logic to identify thyroid-mediated effect patterns in aquatic vertebrates, i.e. currently amphibians. The decision logic includes internationally agreed test guidelines and proposes detailed considerations on how to select relevant assays and interpret the findings. It combines New Approach Methodologies with higher-tiered tests up to refined assessment including population

modelling. If the mammalian dataset, including any in vitro data, is used as the starting point and indicates no thyroid-mediated adversity or mode-of-action, the Xenopus Eleutheroembryonic Thyroid Assay (XETA) may be conducted in place of the Amphibian Metamorphosis Assay (AMA) or its extended, fixed termination stage variant (EAMA) to exclude thyroid-mediated activity in non-mammalian vertebrates. The AMA or EAMA may be performed if there are indications for thyroid adversity in the mammalian dataset or following a positive XETA. The AMA and EAMA inform on both thyroid-mediated activity and potentially population-relevant adversity and consider generalized toxicity occurrence. In evaluating findings, the response patterns of all assay endpoints are considered, including both the consistency and direction of changes. Thyroid-mediated effect patterns identified at the individual level in the amphibian tests are followed by a mode-of-action analysis and where necessary a population relevance assessment. Finally, all data are considered in an overarching weight-of-evidence evaluation. The decision logic can be adapted, e.g., to accommodate fish tests once thyroid endpoints are included therein. It ensures that all scientifically relevant information are considered and that animal testing is minimised, and it can be included in regulatory assessments to facilitate the conclusion on whether substances meet the endocrine disruptor definition for the thyroid modality in non-mammalian vertebrates.

1.13.T-06 Assessing Disruption of Metamorphosis From Concurrent Chemical and Environmental Stressors Using Alligator Gar (Atractosteus spatula) as a Model

Lauren Eagon[1], Vann Boyte[1], Cameron Collins[1] and Jon Doering[2] (1)Louisiana State University Baton Rouge, (2)Louisiana State University

Metamorphosis is a vital transformation that is largely controlled by the thyroid axis and plays a role in the survival and population recruitment of most fishes. The thyroid axis can be disrupted by anthropogenic chemicals found in surface waters and environmental changes, such as fluctuating temperatures. Disruption by these stressors can result in accelerated, delayed, or even prevented metamorphosis causing poor recruitment. In the environment, fishes are concurrently exposed to chemicals and environmental changes which could additively disrupt metamorphosis. However, the additivity of stressors on metamorphosis in fishes is poorly understood. Therefore, this study used a previously developed Fish Metamorphosis Toxicity Test to assess the combined impact of temperature and chemical exposure on metamorphic disruption using the alligator gar (Atractosteus spatula) as a model. The alligator gar was chosen to represent fishes with a dramatic metamorphic transformation compared to the common model, zebrafish (Danio rerio), which has a subtle metamorphic transformation. Fishes with a dramatic metamorphic transformation are overlooked in risk assessments, and a previous study showed that the alligator gar was more sensitive to disruption of metamorphosis by triiodothyronine (T3) relative to zebrafish. Here, alligator gar were exposed to sub-lethal concentrations of T3 (0, 0.15, 0.93, and 5.56ppb) at 24□C and 28□C for the duration of metamorphosis, approximately 5 to 30 days post-hatch. Progression of metamorphic milestones and mortality were recorded. Individuals exposed to 5.56ppb of T3 at 28°C developed jaw deformities, abnormal body proportions, and had the greatest rate of morality at approximately 30%. However, individuals exposed to 5.56ppb T3 at 24 °C developed abnormal body proportions but had no jaw deformities and a mortality rate of approximately 16%. In contrast, individuals exposed to 0.15ppb T3 had a beneficial response, with normal development and an accelerated growth rate relative to controls. Overall, this study demonstrates the additive effect of exposure to greater temperature and T3 on disruption of metamorphosis in a species of fish with a dramatic metamorphic transformation. This research begins to elucidate the risks posed by chemical pollution and environmental change to population

recruitment among fishes with dramatic metamorphic transformations, which include numerous species of economic and ecological importance around the world.

Navigating the Nexus: Advancing Endocrine Disruptor Assessments Through Intersectoral Collaboration and Innovative Science

1.13.P-Tu034 A Database of Fish Short Term Reproduction Assay (FSTRA) Fecundity Endpoint Measurements

Scott Lynn[1], Jaylen Sims[2], Amanda Morgan[3], Sally Mayasich[3], Michael Mathis[4], Kristan Markey[1] and Amy Thomas[3] (1)US Environmental Protection Agency, (2)Oak Ridge Institute for Science and Education, (3)Battelle Memorial Institute, (4)Fort Environmental Laboratories, Inc.

The Fish Short Term Reproduction Assay (FSTRA) is a 21-day aquatic exposure assay designed to measure fish reproductive success and other, potentially mechanistic, endpoints (OCSPP 890.1350; OECD TG 229). It is part of the U.S. Environmental Protection Agency's Endocrine Disruptor Screening Program Tier 1 screening battery intended to identify compounds that may have the potential to interfere with the estrogen and androgen pathways. A systematic literature review was undertaken to identify in vivo studies that have fecundity endpoint measurements consistent with FSTRA test guideline data. Studies associated with the validation of the FSTRA were identified and used as seed articles for multiple searches of the published literature. Expert reviewers screened 3,563 references through a process of reviewing titles and abstracts followed by the full text of articles before compiling a study inventory of experiments contained in each article with fecundity measurements consistent with FSTRA data. Quality control checks were conducted at each phase of the process. A total of 651 references passed to full text review and have, to date, yielded over 90 articles covering more than 118 unique chemicals. In addition, data is being extracted from 52 Data Evaluation Records (DERs) from USEPA that summarize studies performed according to the FSTRA guideline. The USEPA's ECOTOX Knowledgebase (ECOTOX) will be the repository for extracted data from the FSTRA DERs and peer-reviewed publications containing FSTRA-like reproduction and fecundity data. Following the well-established ECOTOX standard operating procedures (SOPs), the extracted data will be in a structured, curated database with detailed toxicity effects along with study design, methods, and test conditions. Once completed, the labelled set of FSTRA peer-reviewed literature studies and DERs will be query-able on the publicly accessible ECOTOX website (www.epa.gov/ecotox). Fecundity endpoint measurements extracted from these in vivo studies will support a performance-based validation of high-throughput assays and computational models as potential alternatives to the current FSTRA Tier 1 screening test.

Disclaimer/Disclosure: This abstract does not necessarily reflect U.S. EPA policy.

1.13.P-Tu036 Retrospective Analysis of Concentration-Response Data From Regulatory Studies Used for Endocrine Disruption Assessment in Fish

Richard Maunder[1], Rebecca Brown[1], Grace Panter[1], Daniel Pickford[2], Lennart Weltje[3], James Wheeler[4] and Laurent Lagadic[5] (1)wca environment Ltd., (2)Syngenta Ltd, (3)BASF SE, (4)Corteva Agriscience UK Limited., (5)Bayer Research & Development Services LLC

Regulatory assessment of endocrine disruption relies upon the evaluation of endocrine activity and related

adverse effects. It has been hypothesised that endocrine-active substances often exhibit low-concentration effects (LCE) and non-monotonic concentration–response (NMCR) relationships. This has led to the assumption that safe thresholds cannot be defined for endocrine-mediated effects in regulatory assessments. To evaluate this assumption, 160 existing regulatory-style fish in vivo studies including 97 different test substances were reviewed. The studies included OECD test guidelines 229, 234, 240 and Zebrafish Extended One-Generation Reproduction Test validation studies. The dataset comprised both known endocrine active substances as well as substances that had been tested without any a priori assumption for their endocrine activity in fish, such as those selected based on exposure pathways (e.g. US EPA Endocrine Disruptor Screening Program List 1). A database of 2,350 individual endpoint responses was compiled and screened for evidence of LCE, NMCR relationships, and non-threshold responses (i.e., endpoints for which a No Observed Effect Concentration was not obtained), based on statistical observations reported within the studies. Occurrence of these findings was low (< 0.5% for LCE and < 3% for NMCR relationships and non-threshold responses). The LCE and NMCR relationship observations were further evaluated for biological and regulatory relevance using a structured decision logic. This screened out observations based on wider study details including endpoint relevance, concurrent effects on survival and growth, and the observed magnitude of response. The retained observations were then assessed in relation to the properties of the substance tested, reproducibility within and between studies, endpoint type, and potential implications for threshold determination. For studies where no threshold was derived, this was usually due to the experimental design (e.g., only three concentrations in Fish Short Term Reproduction Assays), inappropriate concentration setting or statistical artefacts. Overall, no evidence was found to support the hypothesis that LCE or NMCR relationships are common in these fish studies, and most of the observations were screened out when assessed against relevance criteria. These findings do not support the assumption that safe thresholds cannot be established for endocrine-mediated effects from regulatory studies in fish.

1.13.P-Tu037 Sleepy Crabs: Neuroendocrine and Behavioural Perturbations in the Green Shore Crab Following Exposure to an Antidepressant Cocktail

Marie Houédé[1], Nina Ait-Salhi— Derridj[2], Stéphanie Olivier[1], Manon Laurent[2], Emanuelle Thouvenot[3], Tiphaine Monsinjon[1], Cécile Bellanger[4] and Thomas Knigge[1] (1)UMR-I 02 Environmental Stress and Aquatic Biomonitoring (SEBIO), University of Le Havre Normandy, (2)University of Caen Normandy, (3)Polytech Marseille, Aix-Marseille University, (4)University of Caen Normandy, University of Rennes, CNRS UMR 6552 CEEC (Centre for Studies in Ethology and Cognition)

The worldwide consumption of psychoactive pharmaceuticals is consistently increasing since the beginning of the century. Due to incomplete metabolization and insufficient removal by wastewater treatment plants, antidepressants are now frequently detected in freshwater and coastal ecosystems at µg/L levels. Most antidepressants target biogenic amines, notably serotonin. This neuromodulator is highly conserved across metazoans and pivotal to neuroendocrine signalling, thus playing a central role in the communication between the environment and the organs. In Crustacea, serotonin regulates several physiological processes through interactions with neuropeptide hormones. Because antidepressants are designed to inhibit monoamine reuptake transporters, which are also present in invertebrates, they may interfere with moult, camouflage, energy metabolism, behaviour and other functions. This study aimed to characterise the effects of an environmentally relevant mixture of antidepressants on the Green shore crab, Carcinus maenas. Juvenile and adult crabs were exposed for two weeks or one month to eight antidepressants, including a) the selective reuptake inhibitor

fluoxetine and its active metabolite the norfluoxetine as well as paroxetine, sertraline and escitalopram, b) the serotonin-norepinephrine reuptake inhibitor venlafaxine and its active metabolite the o-desmethylvenlafaxine, and c) the tricyclic antidepressant amitriptyline at two exposure concentrations: a reconstructed environmental concentration of the mixture and its 100-fold increased concentration. Analyses suggest that the antidepressants i) increase serotonin levels in crabs, entailing ii) neuroendocrine and behavioural perturbations. Specifically, the regulation of crustacean hyperglycaemic hormone was increased leading to iii) an unexcepted decrease of the glycemia. Exposed crabs displayed iv) changes in locomotion, as evidenced by a decrease in the velocity and total distance covered. The results indicate a depletion of energy reserves resulting in general physiological impairments in crustaceans exposed to antidepressant mixtures in coastal environments.

1.13.P-Tu038 Molecular Signatures of Stress and Endocrine Disruption Induced by Bisphenol Alternatives

Angela Centeno[1], Maria Costa[2], Marta Monteiro[2], Liliya Sokalchuk Sokalchuk[3], Joselyne Caceido[4], Valerie Langlois[5], Ines Domingues[2] and Laia Navarro-Martin[3] (1)Institut National de la Recherche Scientifique, Centre Eau Terre Environnement, (2)University of Aveiro (UA), (3)Institute of Environmental Assessment and Water Research - Spanish National Research Council (IDAEA-CSIC), (4)Institute of Environmental Assessment and Water Research, (5)National Institute for Scientific Research (INRS)

Bisphenol A (BPA) is a widely used endocrine-disrupting compound, increasingly replaced by structural analogues such as bisphenol AF (BPAF) and bisphenol Z (BPZ). However, the neurotoxic potential of these alternatives during early vertebrate development remains insufficiently understood. This study aimed to compare the effects of BPA, BPAF and BPZ by integrating molecular and behavioral endpoints in zebrafish (Danio rerio), and to identify sensitive transcriptomic biomarkers of exposure across developmental stages. Embryos were exposed to BPA, BPAF, and BPZ during two key developmental periods (0–5 and 4–5 days post-fertilization). Behavioral responses were quantified using locomotor activity assays. Several genes associated with endocrine signaling, stress response, apoptosis, and neural function (e.g., cyp19a1b, bcl2, alas, rpe65) were evaluated as potential biomarkers. Behavioral analyses showed no consistent or significant changes in locomotor activity across treatments. In contrast, transcriptomic data revealed strong and compound-specific molecular responses. BPZ induced the most pronounced effects, associated primarily with stress and apoptotic pathways. BPAF triggered multi-pathway disruptions with non-monotonic dose-response patterns, whereas BPA elicited more moderate responses consistent with endocrine-mediated mechanisms. Importantly, comparable transcriptomic sensitivity was observed across both exposure windows, indicating that later developmental stages can be as responsive as early embryonic exposure. Future work will expand the biomarker panel and incorporate additional behavioral endpoints to refine compound-specific signatures and support environmental risk assessment.

1.13.P-Tu039 Assessing the Endocrine Disruptor Potential of Hydrocarbon UVCBs

Rebecca Brown[1], Rhiannon Smith[1], Olivia Tran[1], Kate Roylance[1], Owen Green[1], Delina Lyon[2], Leslie Saunders[2], Kat Colvin[3], Anna Tan Sépot[4] and Nicholas Synhaeve[2] (1)wca environment Ltd., (2)European Fuel Manufacturers Association Division Concawe, (3)Castrol Limited, (4)TotalEnergies

Endocrine disruption (ED) is becoming a topic which is subject to wider regulatory focus, especially following the introduction of classification categories for ED for human health and the environment in the European

Union (EU). ED assessments are complex and data intensive, and multiple mechanisms of action, including effects occurring in the presence of general systemic toxicity, can affect the outcome. The guidance for ED assessment has been published in the EU, which recommends that for UVCBs (substances of unknown or variable composition, complex reaction products or of biological materials), both whole substance data and data for representative constituents will be required.

Here we describe an initial ED data gathering exercise for example UVCBs in a petroleum stream category. Some whole substance in vivo data were available for mammals and screening level data based on quantitative structure–activity relationship (QSAR) and in vitro ToxCast bioassays was gathered for 25 selected representative constituents covering eight hydrocarbon classes. Many of the constituents were found to be outside the QSAR applicability domains of the methods. Also, despite there being in vitro data available for 17 constituents, only data for three were acceptable because analytical data could not adequately confirm the presence of the test item for 14 of the substances, most of which are volatile.

The acceptable in vitro data were useful for prioritising constituents for further investigation, with e.g. biphenyl assigned as low priority, and phenanthrene and fluoranthene both assigned high priority. The other screening data were however of limited value, with no scope for ruling out ED activity or considering whether ED activity might differ within or between hydrocarbon classes. Further work is needed to develop more reliable QSAR models and in vitro data for hydrocarbons. However, given the difficulties with testing already observed in the available dataset, it is currently unknown whether the in vitro tests for ED that are expected to be introduced as information requirements under EU chemical regulations will be suitable for testing certain hydrocarbon constituents (e.g., volatiles) or whole petroleum substances.

1.13.P-Tu040 Interactome Between Dietary Chemicals and Human Nuclear Receptors

Shaohan Zhang[1], Zhipeng Cheng[2] and Hui Peng[2] (1)University of Toronto; Nankai University, (2)University of Toronto

Dietary chemicals represent a major yet poorly characterized component of human chemical exposome. Although many food-derived compounds are biologically active, their biomolecular targets remain largely unknown. New approach methodologies (NAMs) are needed to identify bioactive dietary chemicals and their biomolecular targets. In this study, our recently developed affinity-selection mass spectrometry (AS-MS) platform was employed to screen 1,600 dietary chemicals against a panel of 24 human nuclear receptors involved in endocrine regulation. A total of 114 interactions were identified across 16 nuclear receptors, most of which have never been reported before. The largest numbers of tentative ligands were observed for constitutive androstane receptor (CAR, n = 25), estrogen receptor beta (ERβ, n = 19), pregnane X receptor (PXR, n = 12), retinoic acid receptor-related orphan receptor gamma (RORγ, n = 11), peroxisome proliferator-activated receptor gamma (PPARγ, n = 9), and retinoic acid receptor-related orphan receptor alpha (RORα, n = 9). Tentative ligands were derived from diverse dietary sources, including fruits, vegetables, legumes, spices, medicinal plants, and animal-derived foods. Distinct receptor-associated chemical spaces were observed, with flavonoids and isoflavones among ERβ ligands, coumarin-like compounds among PXR/CAR ligands, and steroid-like molecules among RORγ ligands. Notably, 27 have previously been detected in human blood or urine samples, supporting their relevance. This study reveals a previously uncharacterized landscape of interactions between dietary chemicals and human nuclear receptors. The results demonstrate the utility of AS-

MS as a high-throughput NAM for prioritizing bioactive chemicals.

Protecting Soils—Linking Soil Ecology, Ecotoxicology and Ecological Risk Assessment

1.14.T-01 Evaluating Soil Microbial Community Responses and Stress-Response Gene Expression Under Tire Wear Particle Exposure

Paridhi Singh[1] (1)York University

Tire wear particles (TWPs) are an emerging source of microplastic pollution that accumulate in soils and release a complex mixture of contaminants, including zinc, benzothiazoles, polycyclic aromatic hydrocarbons, and 6PPD-quinone. While recent work shows that TWP exposure alters soil microbial communities and disrupts nitrogen cycling, these studies capture only downstream functional endpoints which are the outcomes of disturbance, not its onset. The molecular stress-response pathways that mechanistically drive community restructuring remain unexamined, leaving a critical gap: we cannot yet detect or interpret TWP-induced disturbance before it propagates to ecosystem function. This study addresses that gap by resolving the mechanistic link between chemical stress and microbial community change, and by testing whether stress-response genes act as early, sensitive indicators of soil disturbance. Using a 90-day greenhouse microcosm experiment with southern Ontario forest soil exposed to environmentally relevant TWP concentrations, we track community composition alongside the transcription of oxidative stress, metal-resistance, and nitrogen-cycling genes, with enzyme activities and soil chemistry providing functional context. We anticipate that chronic TWP exposure selects for stress-tolerant taxa while inducing oxidative stress and metal-resistance pathways, and that these molecular signals precede and predict measurable shifts in community structure and nitrogen cycling. By coupling molecular and community-level responses over time, this work moves TWP risk assessment from documenting damage to anticipating it. More broadly, it advances the use of microbial stress-response signatures as mechanistic early-warning indicators of soil disturbance; a framework which can be extendable beyond TWPs to chronic contaminant exposure generally.

1.14.T-02 Soil Microbial Community Responses to Soil and Foliar Nanofertilizer Application

Jessica Chadwick[1], Hamideh Alanagh[1] and Subhasis Ghoshal[1] (1)McGill University

Nanofertilizers are posited to provide highly efficient, targeted delivery of essential micronutrients to crops. Nanomaterial application in agriculture is commonly performed either through foliar or soil application. Soil application increases the potential transformations that may occur to nanomaterials, with interactions with the soil matrix and soil dwelling organisms likely. Ensuring the safety, as well as efficacy, of nanofertilisers is essential, with nanomaterial interactions in agroecosystems potentially having unintentional impacts on soil microbial abundance and diversity. This study compared effects of foliar and soil-based application of seven nanofertilizers, at environmentally realistic concentrations, on soil microbial communities. We utilised 16S and ITS rRNA metabarcoding of bulk and rhizosphere soil in addition to monitoring core nanomaterial element concentration across the tomato plant tissues. Results indicate that increasing the concentration of soil-based nanomaterial application from 0.3 to 30 ppm had most effect on rhizosphere community diversity, specifically altering Plectosphaerella and Stachybotrys abundance. The core elements of the nanomaterials were also

differentially translocated within the tomato plants, dependent on nanomaterial composition and application method. Determining how nanomaterials impact on the soil environment form an essential part of terrestrial ecotoxicology study and are necessary for making informed assessments of nanomaterial safety in agriculture.

1.14.T-03 From Sludge to Soil: Evaluating the Environmental Fate and Ecotoxicological Impacts of Anaerobically Digested Polypropylene Microplastics on Agricultural Soil Systems

Irem Simsek[1], Jessica R. Velicogna[2], Juliska I. Princz[2] and Banu Ormeci[1] (1)Carleton University, (2)Soil Ecotoxicology Labs, Environmental Testing Laboratories – Central Division, Environment and Climate Change Canada, Ottawa, Ontario K1A 0H3, Canada

Plastic accumulation in wastewater treatment plants (WWTPs) represents a major contamination vector for terrestrial ecosystems, as captured microplastics (MPs) concentrate in sludge and are subsequently applied to agricultural soils as biosolids. While anaerobic digestion (AD) is widely used for sludge stabilization, its role in altering MP properties and the subsequent downstream cascading effects of these "sludge-weathered" MPs on soil health remain poorly understood. This study investigated the transitional fate and ecological impacts of polypropylene (PP) microplastics across the sludge-to-soil pathway, emphasizing agricultural soil exposure after mesophilic digestion. Biochemical methane potential tests were conducted by exposing sludge to pristine and UV-aged PP MPs (38–125 μm) at low, medium, and high doses (1, 10, and 20 mg g^{-1} total solids). Following a 42-day digestion period, the resulting dewatered biosolids containing weathered MPs were applied to agricultural soil microcosms at a loading rate of 10 g biosolids kg^{-1} dry soil. Terrestrial ecotoxicity and soil quality were evaluated through functional endpoints, including barley (Hordeum vulgare) growth performance, microbial community composition shifts via 16S DNA gene sequencing, soil enzyme activities, and macronutrient (nitrogen and phosphorus) cycling dynamics. AD altered both methane kinetics and MP structural integrity, with polymer weathering verified by carbonyl index measurements. Following land application, soils receiving sludge-weathered MPs demonstrated distinct alterations in biochemical indicators. MP exposure modified key soil enzyme activities. These functional changes corresponded with structural shifts in the soil microbiome and varied responses in barley biomass and plant nutrient uptake. By tracking MPs directly from wastewater sludge through treatment and into the terrestrial boundary, this study demonstrates that sludge stabilization processes critically dictate the final physicochemical state of MPs, altering their bioavailability and subsequent ecotoxicological risks to agricultural soil health and crop performance.

1.14.T-04 Uptake of Fluorescent Thermoset Amino Formaldehyde Polymer Microspheres by Barley Grown in Biosolid-Amended Soils

Maria Giulia Testa[1], Irem Simsek[1], Jessica Velicogna[2], Juliska Princz[2] and Banu Ormeci[1] (1)Carleton University, (2)Environment and Climate Change Canada (ECCC)

Microplastics (MPs) are present in terrestrial environments at increasing concentrations, with agricultural soils serving as an important sink due to practices such as plastic mulching and the land application of wastewater biosolids. Once present in soil, MPs may enter the food chain through plant uptake, posing potential risks to human health. However, to date, relatively few studies have investigated the uptake of MPs into plant tissues. To evaluate the uptake and effects of MPs in soil-plant systems, barley was grown in soil amended with 1-5μm fluorescent thermoset amino formaldehyde polymer microspheres. Additional treatments included biosolids

sourced from three different wastewater treatment plants. Plants were grown for two- and four-week periods, after which growth parameters were assessed, including root and shoot lengths, and plant biomass. Plant tissues were analyzed using fluorescence microscopy and optical photothermal infrared (O-PTIR) microscopy to detect MPs. Additionally, soil samples were analyzed to measure changes in microbial activity and microbial DNA using phosphatase and dehydrogenase reductase activities. Fluorescent microspheres were detected in all exposed plant tissues but were absent from control plants, and MP concentrations were consistently higher in the roots than in the shoots. Microscopy observations indicated that MPs were present both on tissue surfaces and within deeper tissue layers. Biosolid amendment significantly increased microbial activity relative to unamended soils, whereas MP addition did not significantly affect microbial activity. Analyses of microbial DNA further characterized potential shifts in soil microbial communities associated with MP and biosolid exposure. The findings of this research demonstrate the potential for MP particles to be taken up by barley and highlight agricultural soils as a pathway for MP transfer into crop systems. The results contribute to understanding the environmental fate of MPs in agroecosystems and their potential implications for food-chain exposure.

1.14.T-05 Plant Toxicity and Community-Level Effects of Metals in Soils at a Former Industrial Site

Kyle Apigian[1] and Meghan Little[1] (1)Woodard & Curran Inc.

Elevated metal concentrations are present in surface soils at a former industrial site in the western United States. The approximately 350-acre site consists of mixed-grass prairie dominated by native and introduced grasses, forbs, and other herbaceous vegetation.

Previous investigations identified potential risks to plants based on exceedances of soil screening benchmarks. To further evaluate these risks, additional soil sampling and ecological assessments were conducted in summer 2023. Surface soils were collected across a gradient of predicted risk, defined by hazard quotients (HQs) calculated using plant effect levels derived from published sources. A plant bioassay using western wheatgrass (Pascopyrum smithii), a species common at the site, was conducted on the collected soils. In parallel, plant community surveys quantified total vegetative cover and the relative abundance of native and non-native species at each sampling location.

Bioassay results indicated that higher total metal concentrations were correlated with reduced root growth in western wheatgrass. Field observations were consistent with these findings, showing that total plant cover decreased as metal concentrations increased. Observations also suggested that the relative proportion of non-native or invasive species was higher at locations with elevated metal concentrations. Together, these findings indicate that toxicity observed under controlled conditions is reflected in shifts in plant community structure in the field.

These findings can inform remedial decision-making and restoration planning for native plant communities at this site and other metal-impacted locations.

1.14.T-06 Nanoplastics and Leached Chemicals From Plastic Mulch and Its Impacts on

Freshwater Phytoplankton

Miguel Eduardo Felismino[1], Ana C. Quevedo[2], Nathalie Tufenkji[2] and Irene Gregory-Eaves[2] (1)Concordia University, (2)McGill University

Despite growing concern over plastic pollution, the environmental fate and ecological consequences of plastics originating from agricultural systems remain poorly understood. Plastic mulch — thin films applied over crop rows to suppress weed growth and regulate soil microclimate — can represent a substantial source of plastic pollution from agricultural practices. In Quebec, the combination of intense UV exposure, physical abrasion, and repeated freeze-thaw cycles can accelerate the degradation of these films, releasing microplastics, nanoplastics, and associated chemicals into soils. These mulch-derived materials could subsequently enter aquatic systems through agricultural runoff where they may impact aquatic biota. To address this concern, this study quantifies the effects of nanoplastics and leached chemicals (together and in isolation) from plastic mulch on freshwater phytoplankton. Using controlled microcosm experiments, we exposed two model species — the green alga Chlorella vulgaris and the cyanobacterium Synechococcus elongatus — individually and in co-culture, to mulch-derived nanoplastics, leached chemicals, and a combined treatment, each at environmentally relevant concentrations. We assessed the effects of treatments on growth, photosynthetic pigments and cell size distribution and found species-specific effects. In green algae, we found that while none of the mulch treatments had impacts on their growth, exposure to leached chemicals can lead to increased chlorophyll-a and a change in their size distribution. We also observed that exposure to mulch nanoplastics resulted in increased growth and phycocyanin in cyanobacteria. Additionally, the growth and phycocyanin of the mixed culture increased in the combined nanoparticles + leachate treatment suggesting that presence of a secondary species can modulate the impacts of the treatments. Our study provides valuable information on the downstream ecological consequences of widespread plastic mulch use and it carries implications for how its risks and benefits may be weighed in agricultural systems.

Protecting Soils—Linking Soil Ecology, Ecotoxicology and Ecological Risk Assessment

1.14.P-Tu227 Toxicity of Neodymium Substances to Soil Invertebrates in a Boreal Soil, and the Impacts of Soil Type, Aging and Leaching on Metal Bioavailability and Toxicity

Patrick Boyd[1], Dina Schwertfeger[1], Heather Lemieux[1], Jessica Velicogna[1], Rick Scroggins[1] and Juliska Princz[1] (1)Environment and Climate Change Canada

A clear gap in ecotoxicological data was identified regarding the impacts of the technologically critical lanthanide neodymium (Nd) on soil invertebrates in boreal soils. To address this gap, two inorganic metal salts ($NdCl_3$ and $Nd_2(SO_4)_3$), an organometallic compound (Nd-2-EHA), and its organic component (2-EHA) were examined. Toxicity exposures were conducted using the earthworm Dendrodrilus rubidus, the collembolan Proisotoma minuta, and the oribatid mite Oppia nitens, in two Canadian boreal soil horizons (i.e. organic and mineral), using standardized soil toxicity test methods; effects included survival and reproduction. Different exposure scenarios were investigated, including aging of test soil for six months, and the impact of leaching on toxicity test endpoints. Differences in species sensitivity were observed, with D. rubidus identified as the most sensitive test species. The study highlighted the importance of reporting chemical parameters within toxicity tests, such as electrical conductivity and pH, to better understand test system influences and factors affecting toxicity. Toxicity estimates from leached and aged $NdCl_3$ exposures provide the least confounded assessment of

Nd toxicity (reproductive IC_{50} for D. rubidus: 890 [767–950] mg Nd/kg dry soil), as leaching reduced salt-related effects. Incorporating measures of bioavailable metal proved valuable for comparing toxicity across metallic substances. Despite the lowest measured bioavailable and total Nd, the organometallic, Nd-2-EHA, was the most toxic compound tested (reproductive IC_{50} for D. rubidus: 17 [10–30] mg Nd/kg dry soil), suggesting that in the unaged soils, toxicity was largely driven by the organic moiety (2-EHA). This is further supported through aging studies, as both Nd-2-EHA and 2-EHA toxicity decreased significantly over time, while metal contents remained relatively stable, indicating degradation of the organic moiety. These findings demonstrate the challenges of using a metal ion read-across approach for risk assessment when organometallic compounds are part of priority substance groupings.

Disclaimer/Disclosure: The present study was funded by Environment and Climate Change Canada, through the Chemicals Management Plan.

1.14.P-Tu230 Assessing the Abiotic and Biotic Impacts of Wildfires on Estuaries With Different Connectivity To Burn Zones

Tony Easton[1], Erika Holland[1] and Christine Whitcraft[2] (1)California State University Long Beach, (2)California State University Long beach

During the Pacific Palisades wildfire in Southern California in January 2025, over 20,000 acres of urban, commercial, and wildland areas were burned along the coast, releasing a variety of pollutants into the environment. Following post-fire rain, the threat to environmental health persists, as wildfires increase erosion rates, facilitating the transport of pyrogenic pollutants such as ash, metals, and polycyclic aromatic hydrocarbons (PAHs) throughout the watershed. While these impacts are well studied in freshwater catchments and coastal waters, most studies overlook their potential impacts in estuaries. The importance of estuaries to the overall watershed and connectivity to coastal ecosystem health, together with the increase in global coastal wildfires, demonstrates the need to outline wildfire impacts in estuaries. To address these gaps, this study assesses temporal shifts in estuaries that may be affected by the Palisades Fire. This study follows a before-after-controlled-impact (BACI) study design by comparing sediment properties such as sediment grain size, sediment pollutant loads, and invertebrate communities in samples collected one year before and for one year after the fires. However, as a preliminary assessment, only sediment metal concentration data will be presented in this study. Samples were collected from five estuaries with varying proximity and hydrological connectivity to the burned regions along the Santa Monica Bay Coastline, with three serving as control sites and two serving as impacted sites. With the increasing frequency of fires in coastal regions worldwide, this work will help advance the current understanding of estuarine responses to wildfires by providing useful data for future post-fire conservation and restoration efforts.

Disclaimer/Disclosure: Funding provided by the Council on Ocean Affairs, Science & Technology (COAST)

Selenium Ecotoxicology—Celebrating the 50th Anniversary of Bill Adams' PhD Dissertation

1.15.T-01 Selenium: 50 Years of Research and Scientific Advances

William Adams[1] (1)Red Cap Consulting

The Toxicity and Residue Dynamics of Selenium in Fish and Aquatic Invertebrates (Adams, Ph.D. dissertation, 1976): Selenium (Se) in the early 1970s was identified as a contaminant in the US resulting from the burning of fossil fuels. Some data existed on Se concentrations in fish in the US Great Lakes and Colorado lakes with elevated water concentrations. Research prior to the 1970s focused on human and animal toxicity and health. Adams performed a series of static and flow-through studies with amphipods, fathead minnows, bluegills, rainbow trout and coho salmon using selenite that typically lasted 48-96 days. The flow-through toxicity studies were conducted using radioactive Se-75. Stable forms of Se (selenate and selenite) were analyzed calorimetrically. Key outcomes of this research showed that uptake and elimination of Se from water was very slow, and high concentrations (mg/L) were needed to cause toxicity to juvenile fish – pointing to the need for dietary exposure. The data provided clear evidence that bioconcentration factors are inversely related to exposure concentrations. Analytical measurements for Lake Erie fish indicated that trophic transfer from invertebrates to fish was less than a factor of two and larger fish had greater concentrations of Se than smaller fish. These early studies, together with the loss of most fish species in Belews Lake, NC (1974-76) due to the release of water with elevated selenite (≥150 µg/L) from a fly ash pond, provided the impetus for numerous research projects and the development of EPA water quality criteria (2005/2016). Key developments over the decades include significantly improved analytical methods, review of Se deposition in bird and fish eggs, Se species sensitivity distributions for fish and birds, understanding the potential for trophic transfer, and differences in bioaccumulation between lotic and lentic aquatic ecosystems. The presentation will trace the development of the science over the last 50 years.

1.15.T-02 Progress and Learnings From Over a Decade of Watershed-Scale Selenium Management

Cybele Heddle[1], Mariah Arnold[1] and Adrian de Bruyn[2] (1)EVR Operations Limited, Sparwood, BC, Canada, (2)ADEPT Environmental Sciences Ltd

In 2014, five metallurgical coal mining operations in southeast British Columbia embarked on a multi-billion dollar journey to manage selenium at a watershed scale. This undertaking was only possible because of the foundational work conducted by Bill Adams and his colleagues. The importance of tissue-based effects thresholds, approaches to developing site-specific bioaccumulation models, and considerations in relating individual exposures to effects on fish populations are just a few of the key elements of this management plan for which we owe thanks to Bill and many others who have followed in his footsteps. We will provide an update on successes (regional improvements in water quality and aquatic health via adaptive management), challenges (surprising effects of water treatment on bioaccumulation), and learnings (highly bioaccumulative organoselenium species and particulate interactions).

1.15.T-03 Assessing Relationships Between Reproductive Development and Ovarian

Selenium Dynamics in Fish

Margot Grimmelpont[1], Erin Murray[2], Vicki Blazer[2], Jennie Christensen[3], James Dunnigan[4], Trevor Selch[4], Brian Balmer[5], Molly Moloney[2], Lauren Zinsser[2], Chris Mebane[2], Travis Schmidt[2] and Jess Brandt[1] (1)University of Connecticut, (2)U.S. Geological Survey (USGS), (3)TrichAnalytics Laboratory, (4)Montana Fish, Wildlife & Parks, (5)U.S. Fish and Wildlife Service

More than a century of surface coal mining in the Elk River Valley (British Columbia) has influenced water quality in the downstream transboundary waters of Lake Koocanusa and the Kootenai River (Canada-USA), including increasing selenium (Se) concentrations over time. Reproduction is among the most sensitive endpoints related to Se exposure in oviparous vertebrates due to the efficient maternal transfer of Se from female fish to eggs, with elevated egg Se concentrations associated with consequences for early life stage viability and increased population level risk. Ecological Se assessments commonly prioritize measures of ovary/egg Se concentrations, yet how this metric relates to exposure for embryos remains poorly understood. For example, ovarian and oocyte development across reproductive periods involve changes in tissue composition that may dilute and/or redistribute Se, decoupling tissue Se concentrations from Se burdens in developing eggs.

This study aimed to better understand how reproductive strategy (synchronous vs asynchronous spawners) and oocyte development (development of ovarian follicles to mature oocytes) affects embryo-relevant Se exposure and risk in fish species present in Lake Koocanusa and the Kootenai River. Ovarian Se concentrations and burdens were quantified across the reproductive season for two species with asynchronous egg development (spawn in batches) prior to spawning (Northern Pikeminnow and Redside Shiner) and one synchronous spawning species (Mountain Whitefish). Selenium concentrations and burdens were subsequently compared to gonadosomatic index and histology-based tissue stages to evaluate changes across reproductive development among species. Finally, laser ablation was used to characterize Se distribution within ovarian histological sections of ovary/egg tissues. Together, these measurements provide mechanistic insights into how ovarian development may influence the timing and magnitude of embryo Se exposure, with potential implications for ecological monitoring approaches.

1.15.T-04 Chronic Exposure to Selenium Through a Natural Diet (Lumbriculus variegatus) Resulted in Endocrine Disruption, and Reproductive Impairment in Zebrafish (Danio rerio)

MD HELAL UDDIN[1], Jinnath Rehana Ritu[1], Som Niyogi[1] and Douglas Chivers[1] (1)University of Saskatchewan

Aquatic ecosystems face increasing threats from selenium (Se) contamination arising from mining activities. Selenium acts as a potent reproductive toxicant in fish at elevated exposure levels; however, the molecular and physiological underpinnings of its reproductive toxicity remain poorly understood. The current study investigated the reproductive impacts of trophic Se exposure in zebrafish (Danio rerio). The Se-exposed benthic oligochaete (Lumbriculus variegatus), with Se body burdens of 0.65 (control), 17 (low), and 43 (high) µg/g dry weight, was fed to adult zebrafish for 60 days to assess the endocrine and reproductive effects of Se. Trophic Se exposure induced significant increases in the gonadosomatic index (GSI) in females and hepatosomatic index (HSI) in both sexes. Moreover, Se exposure resulted in reduced fecundity, smaller egg diameters, and diminished sperm motility and velocity. The hypothalamic-pituitary-gonadal (HPG) axis was disrupted by Se exposure, with downregulation of gnrh, fshβ, fshr, cyp19b, vtg, and erα genes in females, and altered expression

of vtgr, cyp11a, and 3βhsd genes in males. Circulating estradiol (E2) levels decreased in females and males (only with high Se treatment), while 11-ketotestosterone (11 KT) declined in males compared to the respective controls. Plasma vitellogenin (Vtg) also decreased in females but increased in males following dietary Se exposure. Histopathological analysis showed that Se induced ovarian adhesion and oocyte degeneration in females, and degeneration
of Sertoli and Leydig cells in males. Collectively, these findings demonstrate that chronic environmentally relevant dietary exposure to Se decreases reproductive fitness of zebrafish by HPG axis dysregulation, underscoring ecological risks from Se contamination.

Disclaimer/Disclosure: MD HELAL UDDIN was supported by the Dean's Graduate Scholarship at the University of Saskatchewan. This work was supported by the Discovery Grants from the Natural Sciences and Engineering Research Council of Canada (NSERC) to Som Niyogi and Douglas P. Chivers.

1.15.T-05 Effect of Cellular Composition on Bioaccumulation of Selenium

James Elphick[1], Bonnie Lo[2] and Stacey Robinson[3] (1)BQE Water, (2)Simon Fraser University, (3)Environment and Climate Change Canada (ECCC)

In aquatic environments, once selenium has been accumulated and incorporated into cells by primary producers, it is predominantly carried through the food-web as the seleno-amino acids selenocysteine and selenomethionine, which are incorporated into protein structures. However, despite the significant role that protein plays as the site of storage and functioning of selenium, the role of protein concentration in altering the concentration of selenium in aquatic organisms on a dry weight basis has not been widely investigated. The effect of differing concentrations of protein between organisms, as affected by differences in concentrations of other major compositional components of cells (i.e., moisture, lipid and carbohydrate), were assessed using data available in the literature. Lipid concentrations in fish appear to play a significant role in describing differences in selenium concentrations observed between species; between individuals within a species; and in development of ovaries to ripe eggs, as a result of dilution of protein. Similar effects of lipid concentration are also apparent in invertebrates, potentially contributing to variability that is common in measurements of selenium. Based on these data, it appears that cellular composition may materially alter apparent selenium concentrations and help to explain some of the dynamics associated with selenium bioaccumulation and trophic transfer.

1.15.T-06 Selenium Bioaccumulation and Trophic Transfer: Lentic, Lotic, or Aquatic?

Christopher Mebane[1], Erin Murray[1] and Lauren Zinsser[1] (1)U.S. Geological Survey

In the United States, the nationally recommended EPA aquatic life criteria for selenium (Se) are intended to protect 80% of water bodies from risk of Se toxicity to aquatic communities by maintaining dissolved Se concentrations below 1.5 µg/L in lentic waters and 3.1 µg/L in lotic waters. These dissolved criteria concentrations were in turn back calculated from an egg/ovary concentration in fish of 15.1 mg/kg dry weight, a concentration protective of most fish species tested, using water to particulate enrichment factors (EF) and biotic trophic transfer factors (TTF) derived from a compilation of 69 data matches comprising 26 lentic and 29 lotic settings.

We have collected selenium data in the presumed food webs of aquatic communities in a large, oligotrophic

river (the Kootenai River in Idaho and Montana, USA) from 2020-2025. The Kootenai River has an extensive lentic section resulting from the ~124 river km-backwaters from Kootenay Lake, BC, Canada, in addition to a ~105 river km-fast water, lotic section upriver of the backwatered section. Selenium is elevated in the Kootenai River owing to coal mining in a major tributary, the Elk River, BC. Across 9 sampling events at 5 to 6 sites each, we have acquired data on algae, periphyton, suspended particulates, benthic invertebrate tissues (~69 taxa), and tissues from 5 focal fish species. We find that water to particulate EFs are negatively correlated with water concentration and that the lentic/lotic nature of the waterbody is not an important determinant of EFs. TTFs are driven by assumptions of fish's diets and could vary greatly depending on whether fish diets reflect selenium in concentrations averaged across all taxa at a site, or if different fish species have dietary preferences that could increase or reduce TTFs.

Despite the simplicity and elegance of treating selenium risk as being modulated by fixed EFs and TTFs, the reality is more complex. This illustrates the tension between the desires of making aquatic life criteria as scientifically correct as possible, protective against risks from elevated selenium (or any chemical) concentrations in water, and straightforward to monitor and assess compliance

Selenium Ecotoxicology—Celebrating the 50th Anniversary of Bill Adams' PhD Dissertation

1.15.P-We198 From Waterborne Selenium Toxicity Testing to Tissue-Based Criteria and Effects Assessments: 50 Years Since Bill Adams' PhD Thesis

David DeForest[1], Adrian de Bruyn[2], James Elphick[3], Cybele Heddle[4], Mariah Arnold[4] and Kevin Brix[5] (1)Barr Engineering Co., (2)ADEPT Environmental Sciences Ltd., (3)BQE Water Inc., (4)Elk Valley Resources (EVR), (5)EcoTox LLC

Over the last 50 years, our understanding of selenium (Se) toxicity to aquatic life has evolved from standard waterborne toxicity testing of inorganic Se species to testing the dietary toxicity of organic Se species using both laboratory and field-based exposures. Recognizing the importance of dietary organic Se exposures for fish, it was subsequently recognized that aqueous Se concentrations are a poor indicator of toxicity and that tissue Se concentrations for fish and their diets were much stronger indicators of toxicity. In particular, given the effects of maternally transferred Se on larval survival and development, Se concentrations in fish eggs were identified as the most reliable indicator of developmental toxicity in early life stage fish. As of the mid-1990s, fish tissue-based Se toxicity data based on organic Se exposures were available in published and grey literature. Subsets of these data were synthesized in the literature but not analyzed in a consistent manner. Bill Adams initiated the effort to conduct a comprehensive synthesis of the available data to develop recommended fish tissue-based and dietary Se toxicity thresholds for fish. Through this effort, Bill was instrumental in working with the United States Environmental Protection Agency in developing updated Se criteria that included fish tissue components, which led to additional collaborations with jurisdictions in Canada (e.g., British Columbia Ministry of Environment) in developing updated Se guidelines. In this presentation we will review these early efforts, discuss our current understanding of species sensitivity and how these data should be applied in regulatory settings. We then overview our most recent efforts to re-evaluate effects of dietary Se on juvenile salmonid growth and develop Bayesian hierarchical models to estimate responses in untested species.

1.15.P-We199 From Specialty Testing to Routine Monitoring: LC-ICP-MS Selenium Speciation and Bioaccumulation Potential in Environmental Waters

Louis Wagner[1] (1)ALS Environmental Canada

Selenium monitoring has traditionally relied on total or dissolved selenium measurements, but total concentration alone does not identify the chemical forms that control mobility, treatability, bioavailability, and bioaccumulation. As selenium management becomes increasingly important for mining-impacted waters, treatment systems, wetlands, and receiving environments, selenium speciation is moving from non-routine specialty testing toward a practical laboratory method supporting routine monitoring programs.

This poster presents the application of liquid chromatography inductively coupled plasma mass spectrometry [LC-ICP-MS] for selenium speciation in environmental waters. The method separates individual selenium species by chromatography and quantifies them using element-specific ICP-MS detection, allowing discrete measurement of key inorganic and organoselenium species, including selenite [SeIV], selenate [SeVI], selenocyanate [SeCN], selenosulfate [SeSO3], selenomethionine [SeMet], methylselenic acid [MeSeIV], methaneselenonic acid [MeSeVI], and dimethyl selenoxide [DMSeO].

The value of this analysis is not simply identifying “how much selenium” is present, but determining which forms are present and what they imply for environmental behaviour. Selenate is typically more mobile and persistent, selenite is more reactive and biologically available, and organoselenium species can have substantially greater bioaccumulation potential than inorganic forms. LC-ICP-MS speciation therefore provides information that total selenium cannot, helping interpret treatment performance, biological transformation, and the potential for selenium transfer into aquatic food webs.

1.15.P-We200 Experimental Insights on How Chemical Speciation Drives Selenium Accumulation

Michelle Fillion[1], Madison Foster[1], Travis S. Schmidt[1], Christopher A. Hyder[1], Johanna M. Blake[1] and Christopher Mebane[1] (1)USGS

Extraction of coal can increase selenium (Se) concentrations in aquatic systems as seen in the Elk Valley, Canada. Although Se is an essential micronutrient, elevated concentrations in mine-impacted systems can have lasting impacts on the ecosystem. Selenium is generally found in water in the inorganic form as either selenate or selenite and becomes toxic when accumulated in biota. Uncertainty remains regarding how different Se species (i.e., selenite and selenate) influence ecosystem uptake, biotransformation, and ecological responses. To address this uncertainty, we conducted a controlled stream mesocosm experiment using the two dominant inorganic Se species. This experiment included dosing mesocosm streams with concentrations of selenite ranging from 0-20 ppb, selenate ranging from 1-100 ppb, and binary mixtures of the two at a 1:10 ratio. We found that Se concentrations increased in sediment, biofilm and macroinvertebrate tissue as exposure concentrations increased, with an effect of Se speciation on the efficiency of Se incorporation into ecosystem compartments. Sediment, biofilm, and macroinvertebrate tissue in selenite-only treatments accumulated higher total Se concentrations than mixed or selenate-only treatments at similar exposure concentrations. Biofilm responses showed higher chlorophyll a and pheophytin concentrations under high Se conditions and species-specific effects evident at the highest target concentrations. Evidence of biological stress was also observed,

with higher concentrations of methylseleninic acid and dimethylselenoxide measured in high-exposure treatments and in selenite-only treatments. Despite measured Se accumulation, no consistent effect on benthic macroinvertebrate survival was observed across treatments. These results provide experimental context for field observations of Se dynamics in rivers and highlight the importance of Se speciation in ecosystem uptake and exposure pathways.

1.15.P-We201 Quantifying Selenium Species Across Aquatic Food Webs Using LC-ICP-MS

BEN WOZNIAK[1] (1)Brooks Applied Labs, LLC

Over the past five decades, research on selenium (Se) in aquatic ecosystems has substantially advanced our understanding of its biogeochemical cycling, trophic transfer, and reproductive toxicity. Early studies established that the greatest increase in Se concentrations occurs during transfer from the water column to primary producers and that toxicity is primarily driven by bioaccumulation through the food web, largely via dietary exposure. Although subsequent work has clarified many factors influencing Se trophic transfer and biological effects, significant knowledge gaps remain, including understanding why similar water column Se concentrations can result in markedly different levels of accumulation in aquatic food webs.

In the past decade, advances in analytical techniques for characterizing Se species in the water column have revealed the important role of low molecular weight organoselenium compounds (e.g., methylseleninic acid and dimethylselenoxide) in driving bioaccumulation in certain environments. These techniques have furthered our understanding of how aqueous phase speciation influences Se uptake by primary producers. However, because dietary exposures are more significant for higher trophic levels, water column speciation alone is insufficient to explain subsequent transfer from primary producers to consumers. Within organisms Se is metabolized into a broader range of species than those present in the aqueous phase, including both low–molecular weight and protein-bound forms, necessitating different analytical approaches for characterizing Se speciation in biological tissues.

This work highlights the development and validation of new liquid chromatography–inductively coupled plasma mass spectrometry (LC-ICP-MS) methods for quantifying Se species in tissues ranging from algae to fish to bird eggs. Given the chemical similarities between Se and sulfur (S), and emerging evidence correlating S-containing amino acid composition to Se uptake, corresponding S speciation data will also be presented. Application of these methods may help refine our mechanistic understanding of Se trophic transfer and ultimately support improvements in ecological risk assessment and tissue-based regulatory criteria.

1.15.P-We202 Use of Long-Term Dataset To Evaluate How Strongly Selenium Concentrations in Fine Sediment and Fine Particulate Organic Matter Correlate to Selenium Concentrations in Benthic Macroinvertebrate Tissues

Jeniffer Lynch[1], Jennifer Shantau[2] and Sarah Skigen-Caird[1] (1)GEI Consultants, (2)GEI Consultants, Inc.

The U.S. Environmental Protection Agency (USEPA) published a final national criterion for selenium (Se) in 2016 that prioritizes assessment of Se in fish tissue over water. This was a shift from earlier criteria as it

recognized that dietary exposure, not water exposure, drives toxicity. In 2024, the USEPA published technical guidance for implementation of the criterion which recommended use of two methods for the development of Se criteria in streams where use of the national criterion might not be appropriate due to site-specific conditions. One of these approaches, the mechanistic bioaccumulation model (MBM), incorporates data from multiple trophic levels, including Se concentrations in water column, particulate matter, macroinvertebrates, and fish. Se bioaccumulation in aquatic environments occurs at the base of the food web as it transfers from water into particulate matter such as algae, fine particulate organic matter (FPOM), or sediment, followed by trophic transfer from particulate matter into macroinvertebrates and ultimately into fish tissue as a result of dietary exposure. The USEPA noted in the national criterion document that the transfer from Se in the water column into particulate matter can be highly variable, in part, due to the type of particulate matter collected. Therefore, the USEPA currently recommends using sediment measurements only when co-located algae or detritus is sampled. This is based on observations showing a weaker relationship between Se concentration in water to Se concentration in sediments compared to the same analysis between water and algae and detritus. Utilizing a long-term dataset that includes Se concentrations in fine sediment, detritus, and macroinvertebrates from a stream sampled in the Pacific Northwest, we investigated variability in the use of fine sediment versus detritus within the MBM. We have encountered sand-bottomed stream systems in which algae and detritus are not readily available in the amounts necessary for Se analysis; the results of our analyses could be helpful in determining the effect of having only fine sediment samples available for model development in soft-bottomed stream systems.

1.15.P-We203 Investigating Environmentally Driven Selenium Speciation Patterns in Mine Sedimentation Ponds To Inform Adaptive Management

Claire Detering[1], Matthew Tryc[1], Katelyn Stenner[1], Adrian de Bruyn[2], Kara Warner[1], Cybele Heddle[3], Emma van Tussenbroek[4] and Mariah Arnold[4] (1)WSP, (2)ADEPT Environmental Sciences Ltd., (3)Elk Valley Resources (EVR), (4)EVR

For the past five years, a monitoring program for a steel-making coal mine in western Canada has investigated elevated concentrations of bioavailable reduced and organic selenium species observed from the outflow of some mine ponds. Bioaccumulated selenium can cause localized effects on the growth and reproduction of organisms immediately downstream of these ponds. Existing literature documents biological drivers as one mechanism that generates reduced and organic selenium species but there are limited examples of organoselenium behavior in surface water or risk management strategies to mitigate generation of these species and their subsequent discharge into the receiving environment. A focused study design within this program aims to (a) investigate specific pond features that may affect organoselenium generation, and (b) improve understanding of why some mine ponds generate organoselenium and others do not. The field program samples from targeted pond inlets and outlets, sediment porewater and surface water, and vegetated and open areas. Spatial patterns (across multiple ponds in a series) and temporal (seasonal) patterns of selenium speciation are being analyzed, and this presentation discusses the preliminary results and interpretations. Through adaptive management, this monitoring program has successfully characterized how localized concentrations of organoselenium from some mine ponds decrease with distance and do not result in region-wide effects on selenium bioaccumulation.

1.15.P-We205 May I Have a Tissue, Please? A Multi-Species View of Selenium Tissue:Tissue Relationships in the Kootenai River

Erin Murray[1], Chris Mebane[1], Lauren Zinsser[1] and Genevieve Hoyle[2] (1)U.S. Geological Survey (USGS), (2)Kootenai Tribe of Idaho

Risk interpretation and regulatory criteria to manage selenium risks to aquatic organisms are often based on fish-tissue concentrations. Because selenium toxicity in early-life stage fish is thought to stem from maternal transfer to embryos, selenium levels in egg/ovary tissues are considered the most relevant indicator of risk to fish populations. However, establishing a regulatory water-quality criterion expressed as a chemical concentration in fish egg/ovary tissues poses practical problems for monitoring. Capturing gravid fish may be difficult, particularly for species that leave the water body under assessment to spawn in tributaries. Small-bodied fish such as sculpin may be more readily catchable, but laboratory protocols may not accommodate analysis of small-mass tissues. The USEPA's aquatic life criterion for selenium document includes extensive analyses and assumptions for relating selenium concentrations in egg/ovary tissues to concentrations in whole-body or muscle fillet tissues, which may be easier to obtain. In the Kootenai River basin (Idaho and Montana, USA), we have extensively sampled fish tissues to examine selenium patterns across different species, seasons, and water concentrations from 2019 to 2025. We compare concentrations in ovary, liver, muscle, and reconstructed whole-body tissues for species that vary widely in size, diet, range, and spawning cycles; including Prosopium williamsoni (Mountain Whitefish), Oncorynchus mykiss (Rainbow Trout), Richardsonius balteatus (Redside Shiner), Cottus cognatus (Slimy Sculpin), Ptychocheilus oregonensis (Northern Pikeminnow), Lota lota (Burbot), and Acipenser transmontanus (Kootenai River White Sturgeon). Our robust paired sampling datasets allow us to explore selenium in these fish tissues throughout the spawning cycle, comparing observed concentrations to reproductive factors such as gonadosomatic index (GSI) and collection date. We observed positive correlations between liver, muscle, whole-body, and ovary selenium within individuals, though the strength of the relationship varied by species. Some species exhibited significant negative correlations between selenium concentrations in ovary, muscle, or liver tissues and GSI. These results help assess how tissue relations of selenium in Kootenai River fish compare to the relation outlined in the USEPA criterion, particularly regarding the suitability of muscle or whole-body concentrations as surrogates for egg/ovary concentrations.

1.15.P-We206 On the Source(s), Cycling, and Fate of Selenium in the Crowsnest River Watershed (Alberta, Canada)

Colin Cooke[1], Craig Emmerton[1], Jennifer Graydon[1], Andreas Luek[1], X. Chris Le[2] and Paul Drevnick[3] (1)Government of Alberta, (2)University of Alberta, (3)NewRange Copper Nickel

Mountaintop coal mining generates large volumes of waste rock. Weathering of this waste rock releases selenium, which can bioaccumulate to levels that can harm, and even extirpate, downstream fish communities. This is well demonstrated in ecosystems impacted by active mountaintop mining operations; however, less is known about the long-term impacts after coal mines close. Here I will summarize two recent studies from the Crowsnest River watershed, which is located in the southern Canadian Rockies. The watershed hosts two legacy mountaintop coal mines: Tent Mountain and Grassy Mountain. Coal mining at both sites ended in the 1980s; however, recent applications to restart mining have raised considerable concern about the existing – and potential future – impacts to downstream water, sediment, and biota. Selenium concentrations the Crowsnest

Basin reveal a clear spatial pattern, with the Tent Mountain Mine spoil pile revealed as the main source. Selenium concentrations in runoff draining the spoil pile reach as high as 801□□g/L. Downstream of the mine, selenium concentrations in Crowsnest Lake and Crowsnest River are much lower (1–2□□g/L), though elevated relative to regional reference systems unimpacted by coal mining. Similarly, trout and whitefish from Crowsnest Lake contain high concentration of selenium in their tissue, (5–26 µg/g dry weight) that exceed guidelines and are among the highest documented in the literature. Finally, a well-dated sediment core from Crowsnest Lake records major changes in sediment chemistry after mining began. Collectively, our results reveal a basin already heavily impacted by coal mining, to which any new coal mining inputs will be compounded.

2. Aquatic Toxicology, Ecology and Stress Response

Assessing Contaminant Effects in Ecosystems With Multiple Stressors: From Laboratory to Field Studies, Modelling and Risk Assessment

2.01.T.A-01 The Unacknowledged Crisis in Ecotoxicology: Everything Is a Mixture

Lynn McCarty[1] (1)L.S. McCarty Scientific Research & Consulting

The conceptual approach to ecotoxicological testing for regulatory purposes is examination of a single chemical substance at a time. Mixtures are considered a special case with alternative experimental designs and interpretation. However, it can be demonstrated that the standard single substance aquatic toxicity testing design is effectively a mixture test. This is examined using the updated fundamental toxicological principle: dose-causation-response (D-C-R). There are three dose metrics: exposure, whole-body, and site(s) of toxic action. Exposure can be divided into bioavailable and non-bioavailable portions. The whole-body dose is the total amount of substance in the body. This can be subdivided into the amount of test substance at the site(s) of of toxic action and the remaining portion at other locations in the organism. Causation can be subdivided into the dominant mode/mechanism of toxic action at the site (s)of toxic action and other mode(s)/mechanism(s) of toxic action at other sites in the organism (i.e., "side effects'). Response is the sum of the adverse effects due to the dominant mode/mechanism of action plus "side effects". Thus, a single substance toxicity test is actually a mixture test with multiple dose, causation, and response metrics. There are no single substance toxicity tests, only mixture tests.

That everything is a mixture is not a surprise for ecologists; toxicity is just one of a multiplicity of modifying and influencing factors – i.e., the primary field ecotoxicological problem is mixtures of mixtures of factors. For regulatory development translation of toxicological information from laboratory to field requires a better understanding of toxicity (D-C-R), modifying factors, and mixture interactions than is provided by current testing methods and out of domain model extrapolation. In the past simplified regulatory toxicity testing provided the knowledge to create the existing environmental regulatory framework. In the present its limitations are inhibiting knowledge development. What is needed is revised experimental testing designs and interpretation methodologies, better laboratory mixtures knowledge development, and better processes for transfer of laboratory-based knowledge to environmental field conditions. This is critical to enable continuing provision of improvements in regulatory ecotoxicology guidance in the environment where toxicity is just one

of many mixtures of factors that influence environmental health.

2.01.T.A-02 A Moment of Heat, a Lifetime Exposure? Neonicotinoid Accumulation in Aquatic Invertebrates Using Laboratory and Mesocosm Studies With Simulated Heatwaves

Johannes Raths[1], Markus Hermann[1], Clarissa von Au[1] and Juliane Hollender[1] (1)Eawag

Heatwaves and potent pesticides are major threats towards aquatic communities. Yet, their combined effects remain poorly understood. To better understand the mechanisms of these stressor interactions, we performed a case study that examined temperature effects on toxicokinetics of a neonicotinoid pesticide (thiacloprid) in aquatic invertebrates under laboratory and outdoor mesocosm conditions.
This study aimed to overcome existing toxicokinetic modelling limitations for neonicotinoids. This imüplemented by considering their strong receptor binding affinity which causes resistance towards elimination and recovery.
First, we developed a temperature dependent toxicokinetic model, including receptor-binding. The model was calibrated based on laboratory experiments with aquatic invertebrates exposed under static temperature and thiacloprid exposure conditions. Then, experiments were performed using an outdoor mesocosm facility with a dynamic exposure, considering temperature fluctuations and thiacloprid pulses including a simulated heatwave (ambient temperature + 8°C). Online-SPE LC-HRMS/MS was deployed to facilitate the analysis of thiacloprid in water, whole body and membrane protein fractions.
Temperature exponentially increased toxicokinetic rate constants. The temperature dependent toxicokinetic model showed a good fit for laboratory data ($R^2 = 0.78 – 0.98$) and allowed a correlation of temperature effects on toxicokinetics with other physiological parameters (i.e. respiration). Furthermore, the model accurately predicted tissue concentrations in the mesocosm experiment. Under heatwave conditions, tissue concentrations were two times higher at the end of the exposure pulse compared to ambient temperatures (46 vs. 25 µg kg-1). Tissue concentrations persisted at this level also without further exposure - a direct consequence of receptor-bound, elimination-resistant residues.
The presented study advanced the mechanistic understanding of the interaction of chemical exposure and changing climatic conditions. We highlight how extreme heat events can intensify risks caused by pesticides, especially when they show specific biological interactions such as strong receptor binding. These findings emphasize the need for regulatory strategies, such as dynamic models, to address the interaction of contaminants and a warming climate.

Disclaimer/Disclosure: This project was funded by the Swiss national Science Foundation (200020_219277) and the Swiss Federal Office for the Environment (FOEN) with the Climate Change and Freshwater Biodiversity Program.

2.01.T.A-03 Does Thermal Regime Alter Pesticide Risk: Multi-Trophic Effects and Fate of Triticonazole in Freshwater Microcosms Under Ambient and Elevated Temperatures

Banchiamlak Admasu[1], Li Yaoyu[2], Frits Gillissen[3], Paul Van den Brink[3] and Pierina Rivas[3] (1)Wageningen University and Research (WUR), (2)Former student at Wageningen University & Research, (3)Wageningen University & Research

Abstract

Freshwater ecosystems face chemical runoff, yet risk assessments rarely consider how tropical thermal regimes alter ecotoxicity. This study evaluated how ambient (22°C) versus elevated tropical-like (28°C) temperatures mediate the multi-trophic ecotoxicity and fate of the fungicide triticonazole. Using a 2 temperature × 4 triticonazole treatments factorial indoor microcosm experiment using 34 microcosms containing 3 cm of sediment and 12L of natural water and communities comprising phytoplankton, macrophytes (Myriophyllum spicatum), zooplankton, and macroinvertebrates (Gammarus pulex, Lymnaea stagnalis). The microcosms were exposed to nominal triticonazole concentrations (0, 10, 100, 1000 µg/L) for 28 days.

Preliminary results show that dissipation times (DT50) accelerated significantly at 28°C under 1000 µg/L ($p=0.0333$) compared to 22°C, showing that higher temperatures shorten the chemical's persistence period. Physically, the 28°C regime reduced dissolved oxygen ($p<0.001$). Biologically, triticonazole suppressed Myriophyllum spicatum biomass and phytoplankton photosynthetic yield, though the elevated thermal baseline acted as a metabolic promoter, partially counteracting these constraints.

The multivariate technique Principal Response Curves showed that the zooplankton community underwent significant structural shifts driven independently by temperature and triticonazole. Especially cladocerans were reduced in abundance values by both stressors. For decomposers, an interactive threshold emerged; ambient microbial leaf litter decomposition accelerated under low-to-medium triticonazole before dropping at 1000 µg/L, but the elevated temperature altered this tipping point. These direct and indirect effects cascaded to macroinvertebrates, impairing G. pulex feeding behavior and reducing body length.

These findings showed that baseline temperature strongly modifies both the environmental fate and ecological effects of triticonazole. Toxicity assessments based solely on temperate conditions may underestimate risks in warmer and tropical freshwater ecosystems.

Keywords: Microcosm, Triticonazole, Thermal gradient, Multi-stressors, Gammarus pulex

2.01.T.A-04 Combined Effects of Methoxyfenozide and Elevated Temperature on Freshwater Community Structure and Ecosystem Functioning in Outdoor Mesocosms

Imroatushshoolikhah Imroatushshoolikhah[1], Paul van den Brink[1], Ivo Roessink[1], wout Hoppenreijs[2] and sofia Grommenau[2] (1)Wageningen University and Research (WUR), (2)wageningen university and research

Methoxyfenozide, an ecdysone-receptor agonist insecticide is widely used in agriculture which potentially flow and affecting freshwater ecosystem structure and function. On the other hand, climate change is also altering aquatic ecosystems, and the combined effects of climate change and methoxyfenozide remain poorly characterized under environmentally realistic conditions. Therefore, we conducted a 28-day outdoor mesocosm experiment (0, 30, 300 µg/L methoxyfenozide at ambient and ambient + 4 °C temperatures).

Preliminary results showed that methoxyfenozide degraded slowly (56% remained in the water on day 28) and did not undergo warming-induced dissipation. Warming alone shifted the macroinvertebrate community towards heat-tolerant Oligochaeta, Asellidae and leeches while the amphipod Gammarus pulex declined.

Methoxyfenozide alone reduced Chaoborus and other Chironomidae larvae. Similar effects on insect populations were found on the abundance of emergent insects. Multivariate analyses showed that warming and methoxyfenozide concentrations had significant effects on macroinvertebrate community structure, but no interactive effects. It shows that the trophic cascade is driven by methoxyfenozide-induced top-down disruption of the structure of aquatic ecosystems.
The zooplankton community was dominated by the copepod nauplii 49% and the rotifer Polyarthra 30%, which showed both warming and pesticide driving rotifer declines (Polyarthra spp., Keratella spp.), while some cladocerans (Ceriodaphnia sp., Chydorus sp., Acroperus sp.) increased in abundance. Multivariate analyses showed significant effects of warming and the highest methoxyfenozide concentration on the structure of the zooplankton community. The lowest methoxyfenozide concentrations showed some isolated significant effects on community structure, while warming and methoxyfenozide showed a significant interaction effect immediately after application.
It can be concluded that the single stressors altered the invertebrate communities, but they did not show strong interactive effects.
Keywords:
methoxyfenozide, climate warming, multiple stressors, outdoors mesocosm, invertebrates, freshwater ecosystems

2.01.T.A-05 Stream Restoration and Ecological Surprises: Community Responses to Improvements in Water Quality and Habitat Are Influenced by Climate Change and Species Interactions

William Clements[1], Pete Cadmus[2] and Christopher Kotalik[3] (1)Colorado State University, (2)Colorado Parks and Wildlife, (3)U.S. Geological Survey (USGS)

Long-term monitoring and mesocosm experiments conducted with benthic macroinvertebrate communities from the Arkansas River, a historically metal-contaminated watershed, showed that downstream assemblages remain dominated by metal-tolerant species despite significant improvements in water quality over the past 30 years. We investigated several hypotheses to explain the lack of full recovery in a system where metal concentrations are well below chronic criterion levels. Based on long-term studies conducted in other streams, we are confident that three decades is more than sufficient time for benthic communities to fully recover, especially in a system such as the Arkansas River with productive upstream sources of recolonization. We also do not believe that residual metals in this system have inhibited recovery. Mesocosm experiments conducted using benthic communities from numerous Colorado streams, including the Arkansas River, have shown that current levels of metal contamination are unlikely to have any significant effects. However, there is evidence from mesocosm experiments that the establishment of metal-tolerant communities at downstream stations may impede recolonization by sensitive taxa. There is also strong support for the hypothesis that increased density, biomass and foraging efficiency of brown trout (Salmo trutta) as a result of remediation and restoration treatments have increased predation pressure on benthic macroinvertebrates. Finally, long-term changes in physicochemical characteristics of the Arkansas River, including increased water temperature and specific conductance associated with climate change, have likely slowed recovery of benthic communities. Field surveys have shown a shift in community composition at upstream reference sites over the last 15 years and recent mesocosm experiments have documented an unexpected increase in metal tolerance of these communities. Our results demonstrate that long-term responses to restoration treatments are determined by a complex set of biotic and

abiotic factors operating within the context of climate change and that complete recovery may not be achievable in some systems.

2.01.T.A-06 Impediments to the Widespread Use of Multiple Stressor Ecological Risk Assessment in Adaptive Management and Decision Making

Wayne Landis[1] (1)Department of Environmental Sciences, College of the Environment, Western Washington University

This session (and talk) is the latest in a decades long series presenting and advocating for the evaluation of multiple stressors in the decision making and management processes to protect ecological systems. Immense progress has been made but such analyses are few compared to the single class of stressor approach. The increase in the recognition of climate change as an enveloping impact on ecological systems, that microplastics are themselves a group of multiple stressors, and the ubiquity of halogenated lipophilic and persistent organics emphasizes the extant of need to evaluate multiple stressors in ecosystem management. Multiple publications in recent years demonstrate that the tools are available to make risk based evaluations of multiple stressors over large spatial scales. Why are such multiple stressor evaluations uncommon? First, there is not clear regulatory guidance and practice. The foundational toxicological and regulatory guidance documents were completed in the early development of risk based management and have not been updated to address current issues and methods. Furthermore, few toxicological studies have investigated the interactions among multiple chemicals, although it is clearly understood and water and soil contain multiple types of pesticides, plastics, leachates, nanoparticles and the chemicals that result from the environmental transformation of these materials into more toxic compounds. The validity of climate change has been challenged by many political factions. Teaching and training of early career researchers and regulators has also lagged, with emphasis on accepted (and dated) frameworks and methods. However, there are solutions for each of these factors including better training, revisiting old regulatory frameworks, and a broader realization that our current approaches do not accurately represent reality. Examples of each of these solutions will be presented.

Assessing Contaminant Effects in Ecosystems With Multiple Stressors: From Laboratory to Field Studies, Modelling and Risk Assessment

2.01.T-05 Multi-Species Evaluation of Thin Reactive Amendment and Protective Capping (TRaP) System for Tailing-Contaminated Wetland Remediation

Linda M. Campbell[1], Lauren MacDonald[2], Enobong Udoh[1], Heidi Gavel[1], David Lewis[1] and Emily Chapman[1] (1)Saint Mary's University, (2)University of Alberta

Between the mid-1800s and 1940s, gold mining in Nova Scotia, Canada, generated over three million tonnes of finely ground tailings contaminated with mercury (Hg) from amalgamation processes and geogenic arsenic (As). These untreated wastes were frequently discharged into freshwater systems, creating a multi-generational legacy of chronic exposure for aquatic ecosystems. Despite the scale of this contamination—estimated at up to 9.1 tonnes of Hg across 64 mining districts—the long-term aquatic impacts and effective remediation strategies remain insufficiently characterized even 150 years later. Looking forward, our team at Saint Mary’s University is developing in-situ risk management frameworks to address these persistent contaminants. This presentation

synthesizes recent progress in evaluating a Thin Reactive Amendment and Protective capping (TRaP) application—comprising zero-valent iron, bentonite, silica sand, and zeolite—for reducing the bioavailability and mobility of As and Hg in contaminated wetland sediments. To validate the efficacy and ecological safety of TRaP, our team conducted integrated laboratory and field mesocosm experiments using two native bioindicator species: the Eastern Floater mussel (Pyganodon cataracta) and the macrophyte Pickerelweed (Pontederia cordata). Research at Muddy Pond, a historic gold mine-impacted wetland, assessed survival, contaminant bioaccumulation, and physiological stress. In mussels, high-frequency non-invasive valvometry and oxidative stress biomarkers revealed that TRaP treatment significantly increased survival, reduced As bioaccumulation, and increased filtering behavior relative to mussels in the untreated contaminated sediments. Similarly, macrophyte studies demonstrated that TRaP improved seed germination and plant growth while significantly reducing Hg and As concentrations in shoot tissues. Together, these findings demonstrate that TRaP effectively mitigates metal(loid) toxicity and supports the natural recovery of sensitive species in contaminated environments. The data will support the development of a scalable framework for managing legacy As-contaminated mine tailings and protecting the health of freshwater wetland ecosystems in Nova Scotia and beyond.

2.01.T.B-01 Evaluating the Long-Term Effects of Oil Spills and Corixidae Consumption on the Overwinter Physiology of Riverine Fish

Jack Hamm[1], Alex Pelletier[1], Matthew Schultz[1], Rayna Carl[1], Jillian Papke[1], Taylin Young[1], Paul Jones[1], Markus Brinkmann[1] and Tim Jardine[1] (1)University of Saskatchewan

In 2016, over 225,000 L of crude oil entered the North Saskatchewan River (NSR) in one of the largest freshwater oil spills in Canadian history. This study aims to evaluate the long-term impact of this oil spill by determining if riverine fish are still being exposed to oil constituents, how exposure changes over the winter, and whether exposure is mediated by consumption of migratory insect prey which originates from outside the river. The primary constituents of concern are polycyclic aromatic hydrocarbons (PAHs) which are known carcinogens. Fish may feed on riverine prey exposed to the spill, or a migrating species of aquatic insect called water boatmen (Corixidae). Corixidae migrate from lentic wetlands to lotic river systems in the fall and are high in lipids, which are critical components of overwinter survival in fish. Thus, Corixidae consumption could play a major role in offsetting PAH exposure and toxicity in fish. Five target species of fish were caught using gill nets at four different sites along the NSR that range in their distance downstream from the original spill site. This process was repeated over three sampling seasons in October, December, and March to track diet, energy stores and PAH exposure throughout the winter. Stomach content analysis shows that fish do consume Corixidae throughout the winter (mean % of prey mass = 14%, n= 128), although consumption is species dependent and is significantly reduced from fall consumption (mean % of prey mass = 44%, n= 99). Fish liver-somatic index (LSI) increased significantly between the fall and winter seasons with the fall mean LSI being 1.78%, and the winter mean LSI being 2.18%. This spike in LSI is indicative of an overall loss of body weight during the winter due to reduced consumption and slower metabolic rates. PAH metabolite concentrations, determined in bile using high performance liquid chromatography (HPLC), shows that PAHs accumulate during the winter leading to potentially adverse effects, coincident with an overall slowdown in feeding. The late winter samples produced a mean total PAH concentration of 40.6 ± 59.4 ppb, whereas the fall mean total PAH concentration was 14.2 ± 6.0 ppb. These findings highlight the importance of considering both seasonal and dietary effects when assessing exposure risks of riverine fishes.

2.01.T.B-02 Dynamics and Drivers of Mercury Accumulation in Canadian Lake Sediments Over the Past ~200 Years

William Chapman[1], Zofia Taranu[2], Jennifer Pham[1], David Zilkey[1], Hamid Ghanbari[3], Dermot Antoniades[3], Marc Amyot[4], John Smol[5], Carsten Meyer-Jacob[6] and Irene Gregory-Eaves[1] (1)McGill University, (2)Environment and Climate Change Canada (ECCC), (3)Université Laval, (4)University of Montreal (UdeM), (5)Queen's University, (6)Université du Québec en Abitibi-Témiscamingue

Mercury is a persistent, adverse environmental pollutant due to its ability to bioaccumulate and its resistance to biodegradation. Lake sediments provide a record of mercury deposition originating from both local and distant sources. With the intensification of climate and land-use changes across many regions, there is growing evidence that lacustrine mercury cycling and accumulation are changing. For example, increases in dissolved organic carbon (DOC) inputs, associated with climate change and recovery from acidification, can enhance the delivery of mercury to lakes. In contrast, land-use intensification in lake watersheds often increases nutrient inputs and sediment deposition, which can dilute the mercury accumulating in lake sediments. We used sediment total mercury concentrations, together with spectroscopically inferred sedimentary chlorophyll a (which includes its diagenetic products, as an estimate of past overall lake primary production) and lakewater DOC to infer past changes in Hg dynamics from sediment cores collected across ~20 lakes in Canada. We evaluated the relative strength of different drivers of mercury accumulation including both within-lake factors (chlorophyll and DOC) and regional factors (climatic and land-use records) using hierarchical generalized additive models. These analyses help disentangle the relative contributions of individual and interacting drivers of mercury accumulation as recorded in lake sediment archives across Canada.

2.01.T.B-03 Heatwaves and Chemical Mixtures Negatively Impact Recruitment in Wild Frogs (Rana temporaria)

Dominique Anderson[1], Frances Orton[1], Lavanya Vythalingam[1], M. Glória Pereira[2], David Spurgeon[2] and Megan Humpheys[2] (1)Heriot Watt University, (2)UKCEH

Amphibians are the fastest declining vertebrate taxa. The contribution of failed recruitment to declines, and how stressors impact recruitment in wild frogs are not well understood. Stressors such as heatwaves, pollutants, invasive species, and salinisation are known to negatively impact pond habitat quality, where many amphibian species reproduce and complete their aquatic lifecycle. Here, we measured two complementary early-life metrics of recruitment of common frogs (Rana temporaria) in 47 ponds (UK); reproductive success, capturing progression from spawn production to larval establishment; and tadpole persistence, capturing the continuation and progression of larval development toward metamorphosis. Temperature, water chemistry (total dissolved solids, turbidity, pH, salinity, nutrients, pesticides, pharmaceuticals, metals), and invasive species (Pacifastacus leniusculus) presence were recorded. These stressors were analysed within a multi-tiered framework incorporating class-level regression, analyte screening, network analysis, and Bayesian mixture modelling for their potential impacts on both metrics. A twofold increase in heatwave frequency was associated with a 95% reduction in the likelihood of reproductive success. Higher concentrations of flufenacet were a significant negative predictor of reproductive success, reducing the probability of tadpole presence. Bayesian mixture modelling identified a structured co-occurrence of herbicides, fungicides, pharmaceuticals, and thermal stressors negatively associated with reproductive success. For tadpole persistence, twofold increases in cumulative nutrient and pharmaceutical concentrations were associated with 65% and 42% reductions in

likelihood of high tadpole abundance with no specific analytes nor combinations significantly associated with this metric. Further, chemical mixture effects were detectable at concentrations 3–6 orders of magnitude below individual compound LOECs, highlighting the limits of single-stressor approaches for understanding drivers of population decline. Our findings demonstrate that amphibian recruitment failure emerges from distinct, life-stage-specific stressor combinations, with heatwaves, chemical mixtures and nutrients the most important drivers, and prominent contributions from individual herbicides.

Disclaimer/Disclosure: Research funded by the Natural Environment Research Council (NE/X015270/1).

2.01.T.B-04 Surface Water Stressors and a Mechanism of Avoidance in Pelagic Fish Embryos

Christina Pasparakis[1], Robin Faillettaz[2], Claire Paris[3] and Martin Grosell[3] (1)University of California Davis (UC Davis), (2)DECOD (Ecosystem Dynamics and Sustainability), L'Institut Agro, (3)University of Miami

Pelagic fish embryos develop near the ocean surface where they are exposed to multiple environmental stressors, including ultraviolet radiation (UVR), elevated temperatures, and contaminant mixtures. Although these vulnerable early life stages are assumed to drift passively with ocean currents and have little to no control over their mobility, recent evidence suggests they can actively modify their buoyancy in response to environmental stressors. Because many stressors are concentrated in surface waters, changes in buoyancy and vertical position may substantially alter embryo exposure and ecological risk. Exposure to UVR alone, as well as in combination with crude oil and elevated temperatures, induced an early onset of negative buoyancy in developing fish embryos. Recovery of positive buoyancy following termination of stressor exposures further suggests this response is highly dynamic and not solely pathological. To evaluate the ecological significance of this response under natural conditions, we combined laboratory measurements of UVR-induced changes in embryonic specific gravity in mahi-mahi (Coryphaena hippurus) and yellowfin tuna (Thunnus albacares) with biophysical modeling of embryo transport and UV exposure in the Gulf of Mexico. These experimentally derived buoyancy changes were incorporated into the Connectivity Modeling System (CMS) to determine whether stressor-induced shifts in vertical distribution alter UVR exposure in the wild. Model simulations demonstrated that UVR-induced buoyancy changes resulted in deeper embryo distributions and reduced UVB exposure by up to 42% in mahi-mahi embryos and 34.5% in yellowfin tuna embryos, with maximum reductions reaching 53%. Incorporation of experimentally derived LC50 values further showed that buoyancy-induced shifts increased the proportion of embryos predicted to remain below lethal UV exposure thresholds.

These findings challenge the long-standing assumption that pelagic fish embryos are passive particles and demonstrate that relatively small changes in buoyancy can substantially alter exposure to harmful surface-water stressors. More broadly, our results suggest that stressor-induced shifts in vertical distribution may influence early-life stage survival and require a reevaluation of how ecological risk is assessed in positively buoyant pelagic fish embryos.

2.01.T.B-06 Field and Laboratory Evidence of Contaminant-Mediated Sperm Quality Impairment in Fundulus heteroclitus From Urban Rivers

Sabine Malik[1], Tyler Frankel[2], Carys Mitchelmore[3], Candice Duncan[1] and Lance Yonkos[1] (1)University of

Maryland, (2)University of Mary Washington, (3)University of Maryland Center for Environmental Science

Industrially contaminated environments often contain legacy pollutants, many of which can be classified as endocrine disrupting compounds. Fundulus heteroclitus, commonly called the mummichog, is one of the few abundant fish species in these highly contaminated and modified rivers because it can adapt to stressful, rapidly changing environmental conditions. Field-collected populations from the Anacostia River, MD, USA and the Christina River, DE, USA from 2023-2025 have shown potential evidence of secondary consequences to this resilience in the form of male reproductive impairment, including sperm DNA damage quantified using single-cell gel electrophoresis (Comet Assay) and altered sperm motility measured using computer-assisted motility analysis (CASA). However, these systems are highly complex and it is not certain that differences are contaminant-mediated, as exposure occurs alongside seasonal and hydrological stressors, including elevated temperature, low precipitation, and associated water-quality changes. To address this, we conducted broad field sampling across two contaminated river systems with a targeted seasonal field comparison and a controlled laboratory exposure. Reference fish were also exposed by intraperitoneal injection to known doses of dioxin (TCDD), an Aroclor (PCB), and creosote (PAH), with sperm quality assessed at 1, 3, and 6 weeks post-exposure. Results have demonstrated repeated reproductive injury through DNA damage and impaired sperm motility at nearly all contaminated sites across three years of study. In the targeted seasonal comparison between Bladensburg, MD and the reference site, sperm and liver DNA damage appeared to increase naturally as the spawning season progressed, but damage at the impacted site was greatest during hotter, drier sampling periods. Reference fish exposed in the laboratory showed immediate signs of liver DNA damage, while sperm abnormalities were limited until 3 weeks post-injection and increased through the duration of the experiment, suggesting that legacy contaminants can cause field-observed impacts. These results demonstrate the importance of distinguishing direct contaminant effects from seasonally mediated reproductive stress and evaluating how warming and altered precipitation patterns may intensify contaminant-associated impairment.

Assessing Contaminant Effects in Ecosystems With Multiple Stressors: From Laboratory to Field Studies, Modelling and Risk Assessment

2.01.P-Tu068 Using the In Situ Feeding Rate of Palaemon serratus (Pennant, 1777) as a Bioassay for Seawater Quality Monitoring

Julien Gourand[1], Romain Coulaud[1], Arnaud Chaumot[2], Olivier Geffard[2], Anthony Mathiron[3], Aurélie Duflot[1], Agnès Poret[1], Gauthier Trémolet[1], Matthieu Bonnet[1], Jason Jeanne[1], Guillaume Jubeaux[3], Céline Boulangé-Lecomte[1] and Benoit Xuereb[1] (1)Université Le Havre Normandie, Université de Reims Champagne-Ardenne, INERIS, Normandie Univ, UMR-I 02 SEBIO, F-76600 Le Havre, France., (2)INRAE – Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement, UR RiverLy, Ecotox Team, 69100 Villeurbanne, France., (3)BIOMAE, Groupe Carso, 01500 Château-Gaillard, France.

Alteration of crustacean feeding rate is used as a relevant sublethal endpoint for both chemical risk and environmental quality assessments. However, bioassays based on the feeding behavior for marine temperate ecosystems remain underdeveloped especially in the field, despite their ecological relevance. This study aimed to develop an in situ bioassay based on the individual feeding rate (IFR) of the marine prawn Palaemon serratus (Decapoda crustacean) that was designed to discriminate the chemical quality among environmentally heterogeneous stations.

Using a standardized seawater-stable agar-feed material, we investigated the relationship between temperature (8, 12, 16, and 20 °C) or salinity (20, 28, 32.5, and 35 PSU) and IFR (expressed as mg of dry feed consumed per prawn per day) during a 14-day laboratory trial. The relationship between the seawater temperature and IFR was also investigated in situ through five seasonal 14-day field deployments that were performed in Le Havre harbor. Laboratory results demonstrated that both temperature and salinity significantly affected prawn IFR, with the latter displaying the strongest influence. Additionally, we observed that prawns displayed variable but consistent feeding behavior. In situ seasonal deployments confirmed the robustness of the temperature-IFR relationship established in the laboratory.
On the basis of the laboratory and field observations, we propose a robust methodology to integrate the confounding influence of these two environmental factors on the in situ IFR (i.e., by correcting the influence of temperature and salinity using median regression equations). We then applied this methodology to IFR data obtained from 14-day in situ deployments that were performed in 11 environmentally heterogeneous stations of the Normandy coast, which displayed contrasting levels of anthropisation. We showed that the in situ bioassay combined with our methodology for incorporating environmental factors allows to detect significant IFR inhibitions in 6 stations that are not explained by temperature or salinity contrasts.
Overall, these results demonstrate that the IFR modulation of P. serratus can be used as a reliable, sensible and robust behavioral biomarker of the response to chemical contamination, usable for large-scale environmental biomonitoring in environmentally contrasted stations.

Disclaimer/Disclosure: This study was funded by the Agence de l'Eau-Seine-Normandie (AESN), the Region Normandie (EVALL project).

2.01.P-Tu069 Freshwater Biofilms as a Trophic Exposure Pathway for Polyester Microfibres to Benthic Grazers

Daniel Stein[1], Alixandra Schebel[2], Jordyn Broadbent[3], Jordan Musetta-Lambert[2] and Ryan Prosser[1]
(1)University of Guelph, (2)Environment and Climate Change Canada, (3)Environment and Climate Change Canada (ECCC)

Microplastics (<5 mm) are increasingly well-recognized contaminants of emerging concern that are readily detected in freshwater ecosystems. Despite this, their environmental fate and effects, particularly regarding benthic communities, remain poorly characterized. In freshwater environments, biofilms are an important food source for benthic consumers and may facilitate the trophic transfer of microplastic pollution by incorporating suspended particles into the biofilm matrix. Textile-derived polyethylene terephthalate (PET) microfibres are among the most abundant morphologies detected in fluvial systems; however, their interactions with freshwater biofilms and benthic grazers are understudied.
In a laboratory-scale continuous flow bioreactor experiment, freshwater biofilms were cultured under ambient and eutrophic nutrient conditions and exposed to pristine PET microfibres at environmentally relevant concentrations. Microfibre-contaminated biofilms were subsequently used in a 48-h acute exposure assay with the freshwater grazing snail Planorbella pilsbryi. Retention in soft tissues was assessed post-exposure, with half of the snails undergoing a 24 h depuration period to evaluate gut clearance capacity. Mortality and effects on reproductive output (egg clutch production, eggs per clutch, and embryo viability) were assessed. Biofilms were also submitted for fatty acid analysis to evaluate potential changes in nutritional quality associated with microfibre exposure and nutrient status.

This study investigates whether freshwater biofilms act as a vector for PET microfibre exposure to benthic grazers and whether nutrient enrichment influences biofilm-mediated exposure and associated biological effects. Results from this experiment will contribute to more robust models of freshwater microplastic fate and transport and inform ecological risk assessments by incorporating biologically mediated exposure pathways into freshwater food webs.

2.01.P-Tu071 Community- and Organism-Level Responses to 6PPD-Quinone: A Limnocorral Study in a Boreal Lake

Kerri Lynn Ackerly[1], Erin Ussery[2], Kathleen Roark[1], Jose Luis Rodriguez-Gil[3], Lauren Timlick[3], Vince Palace[3], Alon Agua[4], Michael Pirrung[4] and Kristin Nielsen[1] (1)The University of Texas at Austin, (2)Environment and Climate Change Canada, (3)IISD-ELA, (4)University of California Riverside

6PPD-quinone (6PPD-q), a photodegradation product of the tire antioxidant 6PPD, is a contaminant of emerging concern given its acute toxicity to some salmonids – yet its community-level effects remain largely uncharacterized. To address this gap, we deployed 6PPD-q spiked limnocorrals in a natural boreal lake and assessed water chemistry, phytoplankton, zooplankton, and benthic invertebrate communities after 28 days. A single pulse exposure (0-100µg/L) was used to simulate post-storm runoff. Waterborne concentrations fell by 80-99% by the end of the study, with no effects on overall water quality. Chlorophyll-a and zooplankton abundances shifted markedly over time, but these changes reflected seasonal dynamics rather than 6PPD-q, and benthic community composition also showed no treatment related differences. Concurrently, we ran an early life stage exposure using wild-spawned fathead minnow (Pimephales promelas) embryos and 6PPD-q spiked water from the in-lake limnocorrals. The highest concentration (100µg/L) significantly reduced larval survival and altered hatch dynamics, indicating dose-dependent effects on early life stage performance. Sublethal impacts included reduced growth, altered organ morphology, and shifts in energy allocation – occurring at both environmentally relevant (10.6-22.4µg/L) and supra-environmental (100µg/L) concentrations. Together, these results provide the first field-scale assessment of 6PPD-q effects on aquatic communities.

2.01.P-Tu072 6PPD Leaching Study With Rubber Diversion Bladder for Hydroelectric Power Generation

Jack (Jay) Word[1], Tristan Van Leuven[1], Peter Stevens[1], Shahab Karimifard[1], Corey Kleppe[2] and Thom Fischer[2] (1)Spheros Environmental, (2)Electron Hydro

This study was designed to evaluate the potential release of 6PPD-quinone (6PPD-Q) from a rubber diversion bladder intended for use at a hydropower facility in Washington State. 6PPD-Q is a breakdown compound from the parent 6PPD which is used in rubber products to reduce degradation of the rubber from ozone. Salmonid species, particularly Coho (Oncorhynchus kisutch) have been shown to be sensitive to 6PPD-Q exposure. The study estimated the potential 6PPD-Q concentrations in the receiving waters adjacent to the project under two exposure scenarios representing realistic median and realistic upper environmental conditions, with both submerged and intermittently exposed-to-air treatments. Each rubber section (6“ x 6” x ~1” piece) was treated on five sides with Belzona 2211 to leave only the surface material available for leaching. Over a 28-day test period, 6PPD-Q concentrations were measured in water samples collected from control, operational, and environmental treatments.

Control treatments and Belzona-only treatments were non-detect, indicating that the laboratory equipment and coating material were not meaningful sources of 6PPD-Q. The highest concentrations were observed in submerged treatments, with day-28 mean concentrations of 38.7 ng/L for the upper submerged treatment and 36.7 ng/L for the median submerged treatment. Air-exposed treatments produced lower concentrations, with the median air treatment averaging 6.7 ng/L and the upper air treatment averaging 0.76 ng/L on day 28. A single fully Belzona-coated replicate yielded 21 ng/L, suggesting possible migration through the coating material. Overall, the results indicate that submerged exposure conditions produced the greatest 6PPD-Q release, while enhanced upper-condition exposure did not substantially increase concentrations relative to median conditions for submerged treatments.

The results of the laboratory study were used to estimate receiving water concentrations for three representative river flow scenarios, (including; lowest recorded flow, typical low flow, and 25th-percentile flow scenarios). The most conservative scenario, lowest recorded flow, resulted in an estimated 6PPD-Q concentration of 0.00041 ng/L. The results from this study indicated that 6PPD-Q leaching from the installed inflatable bladder is unlikely to result in concentrations that exceed Ecology's 11 ng/L Aquatic Life Criteria threshold or USEPA's 12 ng/L Aquatic Life Screening Value threshold.

2.01.P-Tu074 Analysis of Transcriptional Activity of Genes Related to Stress, Immunity, and DNA Damage on Chironomus riparius Larvae Exposed to Multi-Stress

Ahlam Mohamed-Benhammou[1] and Jose-Luis Martinez-Guitarte[1] (1)National University of Distance Education (UNED)

Cellular metabolism is influenced by environmental conditions, with temperature being a key factor modulating invertebrate metabolism due to their poikilothermy. Climate change could be a major issue to manage, aggravated by the current increase in environmental pollution. Although they play a key role in ecosystems, there is a lack of knowledge about the mechanisms underlying invertebrates' ability to manage multistress. The gap is especially evident in aquatic invertebrates, which are essential in the food web of freshwater ecosystems. In this work, to gain insight into the putative mechanisms involved in the multistress response, the effects of single, double, and triple mixtures of bisphenol A, cadmium, and endosulfan at four temperatures (18, 21.5, 23, and 25 ºC) have been studied. Five genes, related to stress (Hsp70, Hsp90), immunity (Defensin), and DNA damage (XRCC1, NLK, Decay), were selected to examine the impact of these three known toxicants. Fourth-instar larvae were exposed for 1, 2, and 4 days and then frozen individually. The RNA was extracted and retrotranscribed to analyze mRNA levels of the selected genes by Real-Time PCR. As reference genes, actin and glyceraldehyde-3-phosphate dehydrogenase were used. The results suggest a complex, time-dependent response, with time, temperature, and chemicals playing roles, opening new perspectives for mimicking wild conditions. In addition, the complexity of interpreting results is underscored by the number of variables implicated and the potential events that can occur in the cell during short-, medium-, and long-term molecular responses.

Disclaimer/Disclosure: This work has been funded by Agencia Estatal de Investigación (PID2022-136669OB-I00). A.M-B is a recipient of a fellowship from Agencia Estatal de Investigación (PRE2022- 000781).

2.01.P-Tu076 Double the Trouble: Dual Effects of Temperature and Pesticides on Hyalella azteca

Santonio Resonno Jr.[1], S.D.M Chinthaka[1] and Michael Lydy[1] (1)Southern Illinois University

The joint toxicity of chlorpyrifos (an organophosphate insecticide) and atrazine (a triazine herbicide) was compared to chlorpyrifos alone to determine whether their mixture produces greater than additive effects to the aquatic amphipod, Hyalella azteca. These pesticides co-occur in agricultural fields across North America and frequently enter aquatic waterbodies together in elevated concentrations. Bioassays were conducted at three temperatures (10, 20 and 30°C) to examine the impacts of increasing temperature may have on toxicity. H. azteca were exposed to one of five concentrations of chlorpyrifos alone and in binary mixtures with atrazine (spiked uniformly at 200 µg/L). Atrazine alone showed no effect of the Hyalella, while a dose-dependent response was found for chlorpyrifos with lethality increasing with dose. Comparisons between chlorpyrifos alone and the binary mixture revealed significant differences in the LC50 values (concentration that causes 50% lethality in a test population) at the 20°C and 30°C, but not at 10°C. At 10°C there was no significant difference in toxicity between chlorpyrifos and the binary mixture including atrazine. Overall, atrazine potentiated the toxicity of chlorpyrifos to the Hyalella, likely by inducing P450 enzymes, thereby increasing biotransformation of the chlorpyrifos to its more toxic metabolite, chlorpyrifos-oxon. An increase of 10ºC in temperature added to that effect by increasing toxicity further. A possible mechanism for this increase could be an increased uptake of the pesticides due to increased respiration or biotransformation to the more potent metabolite. These findings emphasize the importance of considering multiple stressors when assessing toxicity in aquatic ecosystems.

2.01.P-Tu077 Integrated Effects of Water Acidification and Elevated Temperature on Biodistribution of Copper Nanoparticles in Tilapia Using Bayesian Physiologically Based Toxicokinetic Modeling

Hsing-Chieh Lin[1], Jin-Liang Kuo[2] and Wei-Yu Chen[3] (1)esqLABS GmbH, Saterland, Germany, (2)Department of Biomedical Science and Environmental Biology, Kaohsiung Medical University, Kaohsiung, Taiwan, (3)National University of Tainan

Aquatic ecosystems are increasingly exposed to multiple environmental stressors associated with climate change and anthropogenic contamination. Rising temperature and acidification may alter the distribution and elimination of metal-based nanoparticles in aquatic organisms, potentially amplifying internal exposure and altering toxicokinetic behavior. While copper nanoparticle (CuNP) toxicity has been studied under controlled conditions, how co-occurring shifts in pH and temperature interactively govern CuNP biodistribution across fish tissues remains poorly characterized, representing a critical gap for realistic risk assessment.
This study investigated the integrated effects of pH and temperature on tissue-specific CuNP accumulation in Nile tilapia (Oreochromis niloticus) using a Bayesian physiologically based toxicokinetic (PBTK) modeling framework. Fish were exposed to CuNPs across nine scenarios defined by three pH levels (5.5, 6.5, 7.5) and three temperatures (26, 28, 30°C) for 14 days. Tissue concentrations were measured in gill, kidney, liver, intestine, and muscle. A seven-compartment PBTK model was calibrated via Bayesian Markov chain Monte Carlo optimization to derive scenario-specific posterior TK parameters. Model performance was validated using Monte Carlo simulation. A response surface model (RSM) was then applied to characterize interactive pH–temperature relationships across all estimated parameters.
CuNP accumulation was highest in kidney and liver and lowest in muscle across all scenarios. The gill sorption

factor peaked under acidic and low-temperature conditions, indicating increased uptake under acidification. Partition coefficients and clearance rates in liver and kidney responded nonlinearly to the combined pH–temperature gradient, with interaction effects that could not be predicted from single-stressor responses. Kidney concentrations increased markedly under combined low-pH and high-temperature conditions, consistent with near-future climate projections.
These findings demonstrate that assessments based on single stressors alone may produce biased predictions of CuNP tissue burden, as independent assessments cannot capture interactive effects between pH and temperature. The integrated Bayesian PBTK–RSM approach provides a scalable, mechanistic tool for scenario-based risk assessment of nanomaterials in aquatic systems subject to climate change, supporting advances in multiple-stressor modeling and risk assessment.

2.01.P-Tu078 Chemical Mixtures in River Basins: A Probabilistic Risk Model for Combining Similar and Independent Effects

Jannicke Moe[1], Anders L. Madsen[2], Merete Grung[1], Samantha Martins[1], Sophie Mentzel[1], Gašper Šubelj[3], Frederik Verdonck[4], Karel Vlaeminck[4], Sam Welch[1] and Karel Viaene[4] (1)Norwegian Institute for Water Research (NIVA), (2)HUGIN EXPERT, (3)TC Vode, (4)ARCHE Consulting

Chemical mixtures and potential cocktail effects in aquatic ecosystems are recognised as a threat for river basins worldwide. In Europe, risk assessment for chemical mixtures has been subject to much development and debate in the last decade, but many challenges remain. Probabilistic risk methodologies are becoming more common in both human and environmental risk assessment (ERA) and offer new opportunities for fundamental challenges in ERA, such as the characterisation of mixture risk. The Concentration Addition (CA) concept is commonly used in lower- tier risk assessment (e.g., sum of risk quotients). However, the Independent Action (IA) concept lends itself more easily to probabilistic risk calculation (e.g., joint probability of threshold exceedances).

Within the project ENCORE (ENvironmental CO-exposure and Risk Estimation) we have developed a hierarchical probabilistic model for combining these two concepts, formulated as an object-oriented Bayesian network (OOBN). First, probabilistic risk quotients (RQ) are calculated for individual chemicals, as probability distributions of environmental concentrations divided by a threshold environmental value. Next, the CA concept is applied within groups of substances (e.g., with similar mode of action) by summing the RQ distributions. Finally, the IA concept is applied across the different substance groups, to combine RQ distributions by joint probability calculation ("OR" expressions). Predicted exposure concentrations are obtained from the ENCORE fate model, a process-based model for simulation of daily environmental concentrations in river basins across Europe.

Here we present a case study for a subset of the substances (pesticides) and river basins (in Belgium), as a proof-of-concept. The aims of this presentation are: (1) to demonstrate a novel probabilistic approach to mixture risk characterisation, which combines the classical CA and IA concepts in a hierarchical probabilistic model; (2) to demonstrate the applicability of this approach to the case study; and (3) to consider the potential for upscaling this approach to larger spatial and temporal scales.

Disclaimer/Disclosure: The ENCORE project is sponsored by the European Chemical Industry Council

(CEFIC) as part of the Long RangeInitiative (LRI) under project ECO-66 “Next generation risk assessment methods supporting the identifiction ofenvironmental co-exposures of potential concern”.

2.01.P-Tu079 A Scoping Review of the Combined Effects of Heatwaves and Pollution on Freshwater Invertebrates

Valentin Adelmard[1] and Marc Amyot[1] (1)Université de Montréal

Freshwater ecosystems are highly vulnerable to climate change and anthropogenic pollution. Global climate change is characterized in particularly by an increase in average temperatures, with heatwaves that are more intense, longer and more frequent. While the effects of contaminants are well documented, sometimes in a context of global warming, the impact of heatwaves, either alone or in combination with pollution, remains poorly studied in freshwater invertebrates. A scoping review was conducted to assess the current state of research. The objectives are to: (1) identify and analyze the diversity of heatwave scenarios in experimental studies, (2) assess the distribution of experimental approaches and model species, and (3) identify the outcome indicators most commonly studied by authors. The analysis of this corpus reflects the scientific community’s growing interest in the effects of heatwaves on freshwater invertebrates. However, there is a gap between experimental protocols and the reality of climate trends. Despite the use of robust models such as Daphnia or Lymnaea stagnalis, and the emergence of multi-stress approaches in semi-natural environments, most studies are conducted under controlled laboratory conditions measuring outcome indicators at the individual level without necessarily considering the interactions between heatwaves and pollution. This review highlights the need to integrate more realistic thermal scenarios, multi-stress approaches, and molecular analyses to better predict the resilience of freshwater ecosystems to global changes, particularly in sensitive regions such as the Arctic.

2.01.P-Tu080 Early-Life and Later-Life Metabolic Stress Responses Are Compromised by Developmental Exposure to Polycyclic Aromatic Hydrocarbons (PAHs) in Fish Evolved To Resist PAH Toxicity

Samantha Phelps[1], Nishad Jayasundara[1], Melissa Chernick[1] and Richard Di Giulio[1] (1)Duke University

Evolved resistance to anthropogenic compounds has independently emerged in multiple populations across taxa. While such adaptations can confer survival advantages in polluted environments, they may come at the cost of decreased tolerance to other forms of environmental stress. In this study, we sought to determine the mechanisms by which aquatic pollutant exposures are associated with decreased phenotypic plasticity and reduced stress tolerance later in life in the context of pollution resistance. We focused on a population of Atlantic killifish (Fundulus heteroclitus) that has evolved resistance to polycyclic aromatic hydrocarbons (PAHs) which have been previously shown to have increased susceptibility to abiotic stressors. To determine the mechanisms by which PAH adaptation and developmental exposure affect responses to hypoxia stress, we first collected killifish embryos from PAH-sensitive and PAH-resistant populations and exposed them to PAHs throughout embryonic development. Next, we quantified basal embryonic mitochondrial function and performed transcriptomic analysis both with and without hypoxia exposure. Subsequently, after four months of rearing in clean water, we measured juvenile metabolic rates, additionally testing their later-life responses to hypoxia and thermal stress. We found that killifish from pollution-resistant populations differed in their basal metabolic responses to developmental exposure to PAHs and hypoxia at both early-life and later-life stages.

Notably, PAH exposure during development altered the metabolic response to thermal and hypoxia stress in both sensitive and resistant juvenile fish. These results suggest that evolved resistance to aquatic pollution as well as early-life developmental exposures can reshape metabolic responses to common environmental stressors.

2.01.P-Tu081 Health Status Assessment of the American Lobster (Homarus americanus) in a Shifting Environment

Iván Méndez Loeza[1], Stéphanie Pieddesaux[2], David Deslauriers[1], Marie-Helene Rondeau[3], Evelyne Sigouin[3], Amanda Quiros[4] and Richard Saint-Louis[5] (1)Institut des sciences de la mer de Rimouski, Université du Québec à Rimouski, (2)MERINOV, Centre d'Innovation de l'aquaculture et des Pêches du Québec, (3)Mi'gmaq Wolastoqey Indigenous Fisheries Management Association, (4)Agence Mamu Innu Kaikusseht, (5)Département de Biologie, Chimie et Géographie, Université du Québec à Rimouski

The American lobster fishery is the most valuable in Canada, with landings valued at approximately two billion dollars in 2024. Ongoing global change is modifying coastal ecosystems, affecting lobster energy budgets, distribution, and habitat suitability, while increasing susceptibility to disease and environmental stressors. Fishers from the province of Quebec (Canada) have observed lethargic behaviour in lobsters in certain areas, which has raised concerns among the lobster industry for the quality of the seafood, and among researchers about the effects of environmental conditions on lobsters' health status. This study assessed the spatiotemporal variability of lobster health in coastal Quebec through hemolymph analysis across three Lobster Fishing Areas characterized by contrasting oceanographic conditions. Sampling was conducted during the 2026 fishing season in collaboration with two First Nations associations and one fishers' cooperative, supporting stakeholder engagement and applied environmental monitoring. Metabolic biomarkers, including glucose, lactate, calcium, and pH, were quantified using a portable reflectometer enabling rapid, accurate, and cost-effective on-site biochemical analyses. Biomarker data were combined within the Integrated Biomarker Response (IBR), providing an overall indicator of physiological condition. The IBR was incorporated into generalized additive models to examine relationships with environmental variables (temperature, salinity, and dissolved oxygen concentration). We expect that temporal and spatial variations in environmental conditions will affect the health status of the lobsters particularly at the end of the fishing season or in enclosed bays with shallow depth, when and where bottom temperatures are warmer. Combining the proposed health diagnostic tool with in situ monitoring of sea temperatures, salinity and the emergence of new hypoxic zones, the fishing industry might foresee when and where lobsters experience thermal stress, changes in their molting cycles, and the emergence of diseases. Thus, monitoring the American lobster as a sentinel specie, through its hemolymph chemistry, in collaboration with key partners, will help to detect early signals from multistress exposure, including pollution.

2.01.P-Tu083 Development of Integrated Environmental Monitoring Tools To Assess the Effects of Copper Pit Dewatering on Atlantic Salmon and Its Habitat

Wijdane Limouni[1], Isabelle Lavoie[1], Claude Fortin[1], Valerie Langlois[1], Eva Anders[2], Normand Bergeron[2] and Patrice Couture[1] (1)National Institute for Scientific Research (INRS), (2)National Institute for Scientific Research (INRS) Canada

The proposed dewatering of the Copper Pit by Osisko metals at the former Murdochville copper mine raises questions about its potential impacts on water quality, salmon habitat, and biodiversity in the York River

watershed, Gaspe Peninsular, Quebec, Canada. The aim of this project is to develop an environmental monitoring toolkit based on the combination of physicochemical, ecotoxicological, hydrological, and molecular data to the assessment and long-term monitoring of these impacts. The project will start by characterizing baseline environmental conditions, including water quality, metal contamination, and metal accumulation in fish and biofilms within the York River watershed. The biological effects of metal exposure on juvenile Atlantic Salmon (Salmo salar) and Brook Trout (Salvelinus fontinalis) will be assessed using biomarkers of oxidative stress, genotoxicity, mitochondrial function, and physiological condition. In parallel, the links between metal bioavailability, metal accumulation in biofilms, trophic transfer, and toxicity to aquatic organisms will be investigated. Hydraulic and thermal modelling scenarios will evaluate the potential effects of pit dewatering on flow regimes, water temperature, and salmon habitat. Aquatic biodiversity will be characterized using environmental DNA (eDNA) metabarcoding and targeted molecular assays to detect potential ecological changes in the receiving environment. The resulting datasets will be analyzed with multivariate statistical methods to identify the most sensitive indicators of environmental quality, fish health, biodiversity and habitat condition. Relationships between contaminant exposure and biological responses, habitat characteristics and biodiversity metrics will be examined to identify key drivers of ecosystem change and improve predictive understanding of ecological responses to dewatering activities. The results will provide a basis for the development of sampling protocols, decision-support tools, early-warning indicators, and biomonitoring indicators that can rapidly detect changes in ecosystem condition. This toolkit will provide a robust science-based decision-support framework for environmental monitoring before, during and after dewatering operations, contributing to the adaptive and sustainable management of aquatic ecosystems in the York River.

2.01.P-Tu084 Evolved Resistance to Polychlorinated Biphenyl-Induced Cardiac Deformity and Aryl Hydrocarbon Receptor Activation Varies by Ahr Genotype in Adapted Population of Gulf Killifish (Fundulus grandis)

Kendall Greer[1], Jiwan Kim[2], Ramon Lavado[1] and Cole Matson[1] (1)Baylor University, (2)University of Seoul

The highly contaminated Houston Ship Channel (HSC) on the Texas Gulf Coast has experienced strong selective pressures for decades, driving rapid adaptation in resident Gulf killifish (Fundulus grandis) populations. Adapted killifish present a recalcitrant aryl hydrocarbon receptor (AHR) pathway and reduced developmental cardiotoxicity following embryonic exposure to dioxin-like polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs), legacy organic contaminants commonly found in the HSC. The most resistant populations in the HSC have been shown to have a 77-kb deletion spanning the ahr1a and ahr2a genes, which we previously hypothesized would increase their AHR recalcitrance and resistance to AHR-mediated cardiotoxicity. To test this hypothesis, we evaluated PCB-mediated embryonic cardiotoxicity, AHR recalcitrance (via cytochrome P4501A, 'CYP1A' activity), and mRNA expression of cyp1a, cyp1b1, cyp1c1, ahrr, ahr2, and pxr in adapted population killifish embryos with different ahr deletion genotypes. Our results reveal that levels of resistance and AHR recalcitrance are dependent on ahr deletion genotype. Exposure to PCB-126 causes significantly elevated levels of cardiac deformity and induced CYP1A activity in ahr1a/2a^wt/wt individuals, compared to their ahr1a/2a^del/del counterparts. Further, resistance in adapted population ahr1a/2a^wt/wt individuals is intermediate to adapted ahr1a/2a^del/del and reference ahr1a/2a^wt/wt population individuals, and similar to previously studied populations with intermediate resistance. Preliminary qPCR findings support this intermediate resistance pattern, showing intermediate induced expression levels of cyp1a, cyp1b1, cyp1c1, and ahrr for adapted population ahr1a/2a^wt/wt individuals. Basal expression levels in

adapted ahr1a/2a^wt/wt control embryos were elevated compared to ahr1a/2a^del/del controls in all genes assessed. Because the ahr1a/2a^wt/wt genotype does not restore the AHR pathway to reference population function, the ahr1a/2a deletion cannot fully account for the resistance observed in adapted populations and must be complemented by additional, still unknown, adaptive mechanisms.

Disclaimer/Disclosure: Support was provided by the C. Gus Glasscock, Jr. Endowed Fund for Excellence in Environmental Sciences and the Baylor Center for Reservoirs and Aquatic Systems Research (CRASR). Support was also provided by the National Institute of Health (NIH: P42ES027725 and 1R15ES034885).

2.01.P-Tu085 Neuroactive Compounds Impact the Fitness of Early Life Stages of Native Fishes

Meghan Fuzzen[1], Rachel Dawe[1], Benjamin Nussbaum[1], Leslie Bragg[1] and Mark Servos[1] (1)University of Waterloo

Neuroactive compounds, including antidepressants (e.g. venlafaxine), opiates (e.g. fentanyl), stimulants (e.g. methamphetamine), and illicit drugs (e.g. cocaine) are increasingly detected in surface waters worldwide, with municipal wastewater treatment plant effluent (MWWE) representing a major source to aquatic environments. Many of these compounds have been shown to impact the growth and/or reproduction of fishes at therapeutic concentrations, but few have demonstrated whether there may be effects at environmentally relevant concentrations. The aim of this research is to determine whether neuroactive compounds detected in surface waters in southern Ontario, Canada, negatively impact development, growth, or behaviour, of native fishes. Larval fathead minnow (Pimephales promelas) and rainbow darter (Etheostoma caeruleum) were exposed from hatch until the completion of the transition to feeding to either municipal wastewater effluent (MWWE), or neuroactive compounds in mixtures at environmentally relevant concentrations. In fathead minnows, social preference and response to a conspecific alarm cue were assessed. Similarly, general activity and response to an alarm cue was assessed in rainbow darter larvae. Exposure to MWWE significantly decreased growth in both species. While the neuroactive mixture did not alter survival or growth in either species, swimming activity and responsiveness to a conspecific alarm cue were observed at environmentally relevant concentrations. These findings suggest that exposure to neuroactive contaminants downstream wastewater treatment plant outfalls during critical developmental stages may potentially reduce fitness and contribute to population level impacts in wild fish communities.

2.01.P-Tu086 Combined Effects of Polyethylene Terephthalate Microplastics and Chloroquine Diphosphate on Oxidative Stress Biomarkers in Danio rerio: Implications for Aquatic Environmental Risk Assessment

Laura Moura Félix[1], Cleoni dos Santos Carvalho[2], Renata Fracácio Francisco[3], Paulo Donato Frighetto[4], Heidi Samantha Moraes Utsunomiya[2] and Gabriel Hiroshi Fujiwara[2] (1)São Paulo State University (UNESP), (2)Universidade Federal de São Carlos (UFSCAR), Campus Sorocaba, (3)Universidade Estadual Paulista Júlio de Mesquita Filho - Instituto de Ciência e Tecnologia de Sorocaba (ICTS - UNESP), (4)Instituto Federal de São Paulo - IFSP - Campus Sertãozinho

Aquatic contamination by microplastics and pharmaceuticals is a growing environmental concern due to their persistence and impacts on aquatic biota. The combined effects of these contaminants remain poorly

understood. This study evaluated the effects of chronic exposure to polyethylene terephthalate microplastics (MP-PET) in two particle size fractions, and chloroquine diphosphate (CQ) at four concentrations, individually and in combination, on catalase (CAT) and glutathione S-transferase (GST) activities in zebrafish (Danio rerio). Zebrafish were exposed for 21 days to MP-PET in two size fractions (75–105 µm and 300–425 µm), CQ at 1.8, 0.18, 0.6, and 0.06 µg L^{-1}, and their combinations, totaling 15 treatment groups. After exposure, whole-body homogenates (excluding viscera and head) were assessed for CAT activity via hydrogen peroxide degradation and GST activity via conjugation with CDNB. Data were analyzed by two-way ANOVA followed by Tukey's post-hoc test. Both enzymatic activities were significantly affected by the interaction between microplastic size and CQ concentration ($P = 0.007$ and $P < 0.001$). In the group exposed to the smaller microplastic (MP2), the lowest CQ concentration (CQ4) induced a significant increase in CAT compared to MP2 alone ($P = 0.005$). The combination of MP2 with CQ4 (0.06 µg L^{-1}) also elevated CAT relative to CQ4 alone ($P = 0.001$). Regarding GST, in the absence of microplastics, concentrations CQ2 ($P < 0.001$), CQ3 ($P < 0.001$), and CQ1 ($P = 0.016$) increased enzymatic activity compared to the control. Individually, the larger microplastic (MP1) also stimulated GST ($P = 0.024$). However, under co-exposure, both microplastic fractions abolished the drug effect, reducing GST at CQ2 (MP1 and MP2, $P < 0.001$) and CQ3 (MP1, $P = 0.016$; MP2, $P = 0.006$). These results indicate that pollutant interactions modify individual toxicities in ways not predicted by single-substance assessments, reinforcing the need to incorporate mixture scenarios into aquatic environmental risk assessment.

Disclaimer/Disclosure: This research was funded by the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP), grant numbers 2025/03816-9, 2024/06037-8, and 2017/23781-9.

2.01.P-Tu088 Multiple Stressor Effects of Heatwaves and a Neonicotinoid on Stream Ecosystems

Markus Hermann[1], Johannes Raths[1], Martin Breitenstein[1], Sven Gindorf[2], Leonie Haferkemper[1], Juliane Hollender[1] and Christoph Vorburger[1] (1)Swiss Federal Institute of Aquatic Science and Technology (Eawag), (2)University of Zurich

Multiple stressors posed by climate change and pesticides are major threats for aquatic ecosystems due to unpredictable interaction effects. Their impacts will increase in the future as weather extremes, such as heatwaves, are expected to become more frequent and severe, and the application of increasingly potent insecticides, like neonicotinoids, persists globally. To investigate how climate extremes and pesticides affect lotic ecosystems, we conducted a 7-week field mesocosm experiment employing the "POTAMOS" system consisting of 20 experimental flumes mimicking streams.

All flumes were filled with a mixture of pebbles of different grain sizes and organic matter simulating realistic environmental conditions. Subsequently, all flumes were inoculated with macroinvertebrates from streams in the vicinity of the experimental site. Physical water parameters, including temperature, retention time, and flow velocity were steadily controlled. Three heatwave events were simulated, each lasting 7 days and with +8°C above ambient temperatures following natural daily temperature fluctuations. The neonicotinoid pesticide thiacloprid was spiked at an environmentally relevant concentration (10 µg/L) simultaneously with each heatwave to investigate single and interactive effects. Water quality parameters, invertebrate community structure, as well as ecosystem processes and functions were measured during and after each stressor sequence.

We noted a significant single and combined stressor-induced decline in macroinvertebrate abundance and strong alterations of community composition, with greatest dissimilarity to control under heatwave and combined stressor treatments. Under the combined heatwave and thiacloprid treatment, significantly fewer taxa contributed to different functional feeding guilds (FFG) driven by lower abundances of the most sensitive taxa, including Gammarus sp., Chironomidae, Coleoptera, Hydracarina, Diptera, Baetidae, Hydropsychidae, and Sericostomatidae. Contrarily, the individual stressors had more moderate effects with FFG composition remaining similar to that in control flumes. Finally, structural equation modelling revealed temporal changes of significant direct and indirect effects on macroinvertebrate populations, periphyton, chlorophyll-a, and leaf litter decomposition. Our study highlights the increased risks posed by pesticides under extreme heat conditions and illustrates the threat of interacting stressors for stream ecosystems.

Disclaimer/Disclosure: This project was funded by the Swiss Federal Office for the Environment (FOEN) and the Swiss Federal Institute of Aquatic Science and Technology (Eawag) with the Climate Change and Freshwater Biodiversity Program (CCFB).

2.01.P-Tu089 SystemLink Field Study: Spatio-Temporal Design for Assessing Aquatic-Terrestrial Linkages and Contaminant Dynamics Across Europe

Jakob Wolfram[1], Eric Bollinger[1], Carsten Brühl[1], Mirco Bundschuh[1], Magdalena Damiani Quiroz[1], Tom Dekker[1], Martin Entling[1], Isabelle Ernst[1], Léa Fargette[1], Mario Feifel[1], Felicia Hoffmann[1], Hannah Jansohn[1], Julia Losana Garcia[1], Anja Knäbel[1], Lina Stein[1], Danisa Lione[1], Alessandro Manfrin[1], Clara Mendoza Lera[1], Annabelle Moßgraber[1], Peter Müller[1], Stefanie Müller-Schüssele[1], Vajja Sai Samhitha[1], Jens Schirmel[1], Klaus Schwenk[1], Lee Sickler[1], Hannah Siebert[1], Jürg Spaak[1], Jule Sophie Stern[1] and Ralf Schulz[1] (1)Rhineland-Palatinate Technical University Kaiserslautern-Landau (RPTU)

Aquatic-terrestrial linkages facilitate energy and contaminant transfer between ecosystems, yet large-scale variability in these processes remains understudied. Understanding how hydrological and biological connectivity influences contaminant fate and ecological endpoints requires standardized, multi-regional field monitoring. This poster presents the structure, timeline, spatial scope, and experimental design of the SystemLink field study (2026, DFG Research Training Group 2360), which established a framework to quantify these dynamics across European freshwater systems with a specific focus on pesticides. The study spans 100 locations distributed across 10 regions with two priority sites per region receiving intensified monitoring. Sampling occurred from March to July, with site establishment in March and three main sampling periods in May, June, and July. Thirty standardized methods were applied, encompassing all environmental matrices (aquatic, terrestrial, biotic, and atmospheric). Specific methods included, among others, emergence traps, pitfall traps, water and sediment sampling, vegetation and soil surveys, Light Detection and Ranging (LiDAR) mapping, and environmetal DNA analysis. Each method generated multiple environmental endpoints such as soil moisture, organic carbon content, biomass transfer, insect diversity and contaminant concentrations in water, sediment, and biota. We hypothesized that anthropogenic factors would diminish aquatic-terrestrial subsidy fluxes and alter contaminant distribution in riparian zones. This framework provides a robust baseline for assessing cross-boundary ecological risks and subsequent analysis of landscape-scale drivers. Our findings will advance regulatory understanding of pesticide fate beyond aquatic compartments and inform ecosystem-based management strategies.

Disclaimer/Disclosure: German Research Foundation (DFG) - Research Training Group 2360

2.01.P-Tu090 Global Applied Pesticide Toxicity Trends and the Progress Toward the UN Biodiversity Risk Reduction Target

Jakob Wolfram[1], Dino Bussen[1], Sascha Bub[1], Lara Petschick[1], Larissa Herrmann[1] and Ralf Schulz[1]
(1)Rhineland-Palatinate Technical University Kaiserslautern-Landau (RPTU)

The 15th UN Biodiversity conference (UN GBF, Kumming/Montreal) obligates all countries to reduce pesticide risks by 50% until 2030 (target 7.2). The concept of the total applied toxicity (TAT) was introduced describing pesticide risk trends across aquatic and terrestrial species groups in the US and subsequently proposed as the indicator tracking global progress toward the UN GBF target. Recently, we derived global TAT trends (2013–2019) by weighting applied pesticide masses by ecotoxicity thresholds (n = 15,041) for 625 pesticides covering eight species groups. The overarching goal of this work was (1) to propose a method and assess pathways toward the UN GBF reduction goal and (2) to provide comprehensive global assessments of applied pesticide toxicities across aquatic and terrestrial species groups. We found that the TAT of most species groups has increased, most strongly for terrestrial arthropods and soil organisms, counteracting the global reduction targets. However, only 20±14 pesticides per species group defined >90% of the TAT nationally, highlighting efficient risk reduction pathways. High volume crops, such as maize, soybean, cereals, rice and fruits & vegetables, contribute 76–83% to the global TAT, producing heterogeneous patterns of pesticide toxicity pressures that offer additional insights into local or regional areas of concern. Large agricultural producers, namely China, Brazil, USA and India, contribute 53–68% of the TAT globally, due to their extensive croplands coupled with highly intensified agricultural practices. Furthermore, some biodiversity hotspots (e.g., Costa Rica, Guatemala, Central Africa) exhibited the most pronounced annual TAT increases (5–64%) across species groups as agricultural systems are rapidly intensifying. We showed that substantial actions (e.g., shifts to less toxic pesticides, land conversions), will be required globally to approach UN targets as most nations are currently moving away from it. Availability of pesticide application data remains a challenge for accurately tracking the progress toward the UN GBF target of 2030 and beyond, prompting the need for collaborative data collection and sharing globally. In this talk, we want to provide a global overview on the current status and trends of applied pesticide toxicities and the progress toward the UN GBF target.

Disclaimer/Disclosure: DFG SCHU 2271/20-1

2.01.P-Tu091 Transcriptomic Effects of Lampricides and Temperature on Sea Lamprey

Andrea Chandler[1], Tim Zhao[2], Michael Wilkie[2] and Ken Jeffries[1] (1)University of Manitoba, (2)Wilfrid Laurier University

In the early-mid 1900s, sea lamprey (Petromyzon marinus), a jawless parasitic fish native to the Atlantic Ocean invaded the Laurentian Great Lakes through human-made shipping canals. Combined with overfishing, this invasion decimated the populations of several key fishery species including lake trout (Salvelinus namaycush), lake whitefish (Coregonus clupeaformis), and cisco (Coregonus artedi). For over sixty years, the lampricides 3-trifluoromethyl-4-nitrophenol (TFM) and niclosamide have been used to manage sea lamprey populations. Added to streams, lampricides target larval sea lamprey. However, the larvae have been shown to be more tolerant to lampricides in warmer temperatures, making it possible that lampricide use may grow as water

temperatures increase in the Great Lakes with climate change. To learn more about the underlying mechanism of this greater lampricide tolerance in warmer waters, our project aims to investigate how lampricide exposure at different temperatures affects the transcriptome of larval sea lamprey. Larval sea lamprey were acclimated to one of three temperature groups (8°C, 16°C, 24°C) for at least three weeks before toxicity. Acute toxicity tests were then performed to determine the TFM and TFM/niclosamide mixture 12-h LC25, the concentration of TFM which caused 25% mortality in the test animals by 12 h. The larvae were then exposed to the mean 12-h LC25 across the three temperatures, during which sub-sets of individuals were euthanized and sampled for liver and gill tissue at 4, 8, and 12 h of exposure, and after 24 h of recovery in lampricide free water. Total RNA was extracted from tissues and the transcript abundance of select genes will be measured using qPCR. The mRNA expression of genes related to Phase I, II and III detoxification, including cytochrome P450 and the UPD-glucuronylsyltransferase (UGT) enzyme families, and abc transporters, were then measured. We also plan to compare transcripts related to oxidative stress, apoptosis, heat shock proteins, and growth/proliferation. Overall, this project will further our understanding of the detoxification of lampricides at warmer temperatures, and shed light on the underlying physiological mechanisms of greater lampricide tolerance in larval sea lamprey which may inform lampricide application strategies.

2.01.P-Tu092 From Microbes to Megafauna: Investigating PFAS Fate and Transfer Across Estuarine Food Webs

Romina Dotson[1], Paige Powell[1], Melissa Walker[1], Gregory Aniolek[1], Bryan Frazier[2], Zachary Padgett[1], Ashley Galloway[2], Kylie Rock[1], Jessica Donaldson[3], Joseph Bisesi[3], John Bowden[3], Bentley Boyd[1], Matt Heselton[1], Barbara Campbell[1], Dinuka Patabandige[1], Scott Hamilton-Brehm[4], Norm Shea[2], Ethan Friend[2] and Andrew Tweel[2] (1)Clemson University, (2)South Carolina Department of Natural Resources, (3)University of Florida, (4)Southern Illinois University

Estuaries provide critical ecological services but are increasingly impacted by per- and polyfluoroalkyl substances (PFAS), persistent contaminants that can influence microbial processes and bioaccumulate through food webs to apex predators. Understanding PFAS fate in these ecosystems requires investigation across trophic levels, from microbial communities that regulate biogeochemical cycling to sharks that integrate contaminant exposure over time. Microbes play a critical role in estuarine nutrient cycling and contaminant transformation, yet their interactions with PFAS remain poorly understood. We hypothesize that some estuarine microbial taxa can tolerate or potentially transform PFAS, resulting in shifts in community composition, microbial activity, and carbon cycling. To test this, sediment-derived microbial communities from developed and less-developed South Carolina estuaries were exposed to PFOS in culture experiments. After 30 days, PFOS-exposed cultures exhibited greater microbial abundance than controls, while NMR analyses indicated declining PFOS concentrations over time. These findings suggest that PFOS may influence microbial growth and activity and warrant further investigation into potential transformation pathways. Ongoing studies are using 16S rRNA gene sequencing, targeted HPLC-MS/MS, and measurements of total organic carbon, carbon dioxide, and methane production to evaluate changes in microbial community structure, PFOS fate, and carbon cycling.To evaluate how PFAS move through higher trophic levels, we are also investigating PFAS bioaccumulation in finetooth (Carcharhinus isodon) and sandbar (Carcharhinus plumbeus) sharks from South Carolina estuaries. Using HPLC-MS/MS, PFAS concentrations are being quantified in shark plasma and muscle as well as in environmental media and prey species to characterize trophic transfer pathways. Preliminary results indicate species- and life stage-specific differences in PFAS burdens, with finetooth shark neonates exhibiting

significantly lower concentrations than subadults and adults, while patterns differed in sandbar sharks. Together, these studies provide a food-web perspective on PFAS dynamics in estuarine ecosystems, linking contaminant processing by microbial communities to bioaccumulation in apex predators.

2.01.P-Tu093 Herbicides Under a Different Light: Phytoplankton Responses to Mesotrione and Fomesafen Under Variable Light and Nutrient Conditions

Sandrine Picotte[1] and Philippe Juneau[2] (1)University of Quebec in Montreal (UQAM), (2)Institut des sciences de l'environnement, Département des Sciences Biologiques, TOXEN – EcotoQ, Ecotoxicology of Aquatic Microorganisms Laboratory, Université du Québec à Montréal, Succursale Centre-ville, C.P. 8888 Montréal, Québec, H3C 3P8, Canada

Agricultural activities are well-established sources of herbicide and nutrient contamination in adjacent aquatic environments, primarily through surface runoff and soil leaching. This issue is particularly relevant to the Yamaska River watershed (Qc, Canada), where herbicide and nutrient concentrations frequently exceed Canadian water quality guidelines. Some herbicides of emerging concern (HEC), including fomesafen and mesotrione, remain comparatively understudied and no water quality guidelines have been yet established. Fomesafen and mesotrione may disrupt enzymatic pathways involved in the biosynthesis of photosynthetic pigments, respectively affecting chlorophylls and carotenoids, thereby potentially affecting primary production. The effects of mesotrione on primary producers are known to vary with environmental factors, such as light intensity. However, the combined effects of light conditions, nutrient availability and fomesafen exposure remain poorly understood.

This study therefore aims to assess the physiological and metabolic responses of phytoplanktonic species isolated from the Yamaska River to environmentally relevant concentrations of two HEC, mesotrione and fomesafen, applied individually and in combination, under contrasting light and nutrient conditions.

Preliminary results showed a concentration-dependant inhibition of photosynthetic activity in Microcystis aeruginosa following a 72h mesotrione exposure. In contrast, exposure to 1 µg/L mesotrione appeared to confer a relative advantage to Raphidocelis subcapitata during acute high-light stress and subsequent recovery under very-low-light conditions. These findings suggest a weak or potentially antagonist interaction between light conditions and mesotrione exposure at environmentally relevant concentrations. This response differs from effects reported in other studies using mesotrione concentrations in the mg/L range.

Overall, our preliminary findings indicate that interactions among herbicide exposure, light conditions and nutrient availability may produce complex and species-specific responses. This study emphasizes the importance of incorporating multiple environmental stressors into ecological risk assessments and may help identify combinations of agricultural practices that pose the greatest risks to non-target primary producers.

2.01.P-Tu094 Transgenerational Toxicity of Pollutant Mixtures in Danio rerio: Public Health Implications and Environmental Degradation at Madín Dam, México

Alba Lucero García-Medina[1], Marcela Galar-Martínez[1], Sandra García-Medina[1] and Leobardo Manuel Gómez-Oliván[2] (1)Escuela Nacional de Ciencias Biológicas, IPN, (2)Facultad de Química, UAEMex

The Madín Dam is a prime example of environmental degradation in an urban water body subjected to multiple anthropogenic pressures. This reservoir, which supplies water to tens of thousands of residents in the northwestern part of the Valley of Mexico, has for years received municipal discharges without adequate

treatment, such as leachate from the Tepatlaxco landfill as well as inflows from the Tlalnepantla River, which carries urban, industrial, and agricultural pollutants. Consequently, elevated concentrations of heavy metals such as aluminum, iron, and mercury have been identified in the water, exceeding even protective criteria for aquatic life, as well as polycyclic aromatic hydrocarbons, pesticides, and a wide range of emerging contaminants, including pharmaceuticals such as metformin, nonsteroidal anti-inflammatory drugs, and antibiotics.

In this study, the transgenerational effects of environmentally relevant concentrations of aluminum, imidacloprid, and metformin—similar to those found in the Madín Dam—were evaluated. Parental exposure (F0) in the Danio rerio model over 30 days induced significant alterations in the gonadosomatic index and a synergistic reduction in fecundity and fertility. In the progeny (F1), which was not directly exposed, changes in T4 hormone levels and a complete collapse of larval survival were observed 90 days post-fertilization. Furthermore, the gene expression profile revealed processes of oxidative stress, apoptosis, and endocrine disruption in the brain, liver, and gonads. These findings confirm that exposure to complex mixtures induces molecular and endocrine damage that compromises reproductive capacity and offspring success, underscoring the urgency of implementing regulatory strategies and nature-based solutions in urban water bodies across Latin America.

2.01.P-Tu095 Dynamics and Accumulation of Pollutants in the San Pedro Cholula Wetland: Challenges for Conservation in the Upper Lerma Basin

Alejandra Cortes-Lopez[1], Sandra García-Medina[1], Marcela Galar-Martínez[1] and Fortunata Santoyo-Tepole[1]
(1)Escuela Nacional de Ciencias Biológicas, IPN

The San Pedro Cholula Wetland (HSPC), located in the State of Mexico, is a critical ecosystem that acts as a buffer and natural filter within the Upper Lerma River Basin. However, intense human activity in surrounding urban and agricultural areas has led to the introduction of various pollutants that degrade its environmental quality. The objective of this study was to identify and quantify the presence of organochlorine pesticides, metals, and pharmaceuticals in surface water and sediments during the dry and rainy seasons.
Using advanced analytical technologies such as GC-MS/MS, ICP-OES, and HPLC, it was determined that contaminant concentrations increase during the rainy season due to rainwater runoff. Significant levels of pesticides (DDT, dieldrin, and chlordane) and metals (chromium, selenium, thallium, and vanadium) were detected, exceeding the permissible limits established by Mexican and international regulations. Additionally, the presence of emerging contaminants, specifically ibuprofen and naproxen, was confirmed.

The findings underscore that, while the HSPC functions as a nature-based solution for improving water resources, the persistent accumulation of toxins in sediments—a matrix for which there are no regulations in Mexico—poses a risk to the health of aquatic organisms and the stability of the ecosystem. This research emphasizes the urgent need to strengthen environmental monitoring and regulatory policies to mitigate degradation in Latin American wetlands.

Assessing Toxicity in Water and Aquatic Sediments

2.02.T-01 Early-Life Iron Exposure Disrupts Dopaminergic Function and Neurobehaviour in Developing Zebrafish

Nhi Nguyen[1], Mohammad Naderi[2], Theanuga Chandrapalan[3] and Raymond Kwong[3] (1)Biology Department, York University, 4700 Keele Street, Toronto, ON M3J 1P3, Canada, (2)Centre for Functional and Metabolic Mapping, Robarts Research Institute, Western University, London, ON N6A 5K8, Canada, (3)York University

Iron is an essential trace metal in vertebrates. However, excess iron can catalyze the formation of reactive oxygen species, leading to oxidative stress. Unfortunately, the consequences of iron overload during early neurodevelopment remain poorly understood. This study investigated whether elevated iron exposure during early life disrupts neurodevelopment and its potential long-term outcome in zebrafish. Zebrafish embryos were exposed to ferric ammonium citrate from 0 to 5 days post-fertilization (dpf). The effects of iron treatments were investigated at 5 dpf (larval stage) and 21 dpf (juvenile stage) using behavioural and molecular assays. Early-life iron exposure significantly reduced locomotor activity and impaired habituation learning at 5 dpf in a concentration-specific manner. These behavioural deficits coincided with increased apoptosis, elevated lipid peroxidation, reduced expression of dopaminergic markers (th1, comta, and comtb), and signs of disrupted dopaminergic system. This suggests a potential association among iron accumulation, dopaminergic dysfunction, and behavioural impairments. Although behavioural deficits were no longer observed at 21 dpf, fish exposed to high iron concentrations continued to exhibit elevated lipid peroxidation. This persistent oxidative stress was accompanied by increased expression of antioxidant and iron-regulatory genes, indicating potential compensatory responses that may support functional recovery. In summary, iron overload during a critical developmental window can disrupt neurobehaviour and dopaminergic function, with oxidative damage persisting beyond the exposure period. The study highlights the importance of maintaining iron homeostasis during early development and provides mechanistic insight into how environmentally relevant metals may affect neurodevelopment.

Disclaimer/Disclosure: The research was supported by the Canada Research Chairs Program, Discovery Grant from the Natural Sciences and Engineering Research Council of Canada (NSERC), Canada Foundation for Innovation John R. Evans Leaders Fund, and Ontario Research Fund.

2.02.T-02 Antibiotic-Induced Disruption of the Gut Microbiome Alters Oxalate Homeostasis in a Freshwater Fish Model, the Sailfin Molly (Poecilia latipinna)

Felicia Rajan[1] and Carol Bucking[1] (1)York University

Antibiotics are common freshwater contaminants originating from wastewater effluent and aquaculture. An estimated 31% of antibiotics consumed annually by humans is released into river systems. Furthermore, ~80% of global aquaculture occurs in freshwater environments, where studies suggest that 70–80% of administered antibiotics are excreted directly into the surrounding water. We investigated how broad-range antibiotic treatment alters oxalate homeostasis in freshwater sailfin mollies (Poecilia latipinna) through effects on the gut microbiome and host transport processes. Fish were fed either a control or antibiotic-treated diet, and gut microbial metabolic activity, tissue oxalate concentrations, and oxalate transporter expression were examined. KEGG (Kyoto Encyclopedia of Genes and Genomes) pathway analyses demonstrated reduced overall microbial

metabolic activity in the gut microbiome of antibiotic-treated fish relative to controls. Amino acid metabolism and oxalate metabolism were also reduced following antibiotic treatment. Plasma and urine oxalate concentrations increased in antibiotic-treated animals, suggesting impaired microbial oxalate degradation and increased systemic oxalate burden. Oxalate concentrations increased in the anterior intestine and kidney, decreased in the liver, and remained unchanged in the posterior intestine. SLC26A3 (solute carrier family 26 member 3) and SLC26A6 (solute carrier family 26 member 6) are involved in oxalate absorption and secretion, respectively. SLC26A3 expression decreased in both intestinal regions following antibiotic treatment. SLC26A6 expression remained unchanged in the anterior intestine, decreased in the posterior intestine, and increased in the kidney, indicating a compensatory reliance on renal oxalate excretion when oxalate-degrading gut bacteria are disrupted. Gut sac experiments further demonstrated that antibiotic treatment altered oxalate transport dynamics in both intestinal regions. Distinct patterns of intestinal zonation were evident for the gut microbiome, oxalate concentrations, and oxalate transporter expression. Despite substantial renal oxalate excretion in freshwater fish, microbial oxalate degradation remained an important component of oxalate homeostasis. Our findings indicate that antibiotic-induced disruption of the gut microbiome increases systemic oxalate burden and alters host transport responses, potentially affecting physiological homeostasis in non-target freshwater fishes.

2.02.T-03 Leveraging Existing Monitoring Networks To Evaluate Integration of New Approaches in a California Pilot Study

Bushra Khan[1], Manoela De Orte[2], Anna Feerick[1], Erica Kalve[2] and Thomas Young[1] (1)University of California Davis (UC Davis), (2)California State Water Resources Control Board

The Stream Pollution Trends Monitoring program (SPoT) is a statewide program initiated in 2008 under the Surface Water Ambient Monitoring Program of the California State Water Resources Control Board. The program provides critical information on the condition of California waterways to state, regional, and local management programs. Given the expanding complexity of aquatic pollution and increasing costs of routine monitoring, new approaches are warranted to adequately assess waterbody impairments. To this end, integration of new analytical and diagnostic tools is being evaluated to equip the program with more comprehensive information. In a collaborative study, non-targeted analysis (NTA) and in vitro receptor bioassays were utilized to explore contaminant prioritization and site-specific trends. Sediment and water samples were assessed for toxicity using routine testing with Hyalella azteca, Chironomus dilutus, and Ceriodaphnia dubia. Samples were also analyzed using liquid and gas chromatography with high-resolution mass spectrometry for NTA and chemically activated luciferase gene expression (CALUX) for receptor activity evaluations. Results from standard toxicity testing using whole organisms were compared to a suite of eight receptor activity assays to identify site-specific toxicity contextualized with contaminant data. Additionally, toxicity linkages were assembled by identifying NTA feature correlations with standard toxicity markers and CALUX results. These linkages enable selection of chemical features related to potential biological impairments. Preliminary CALUX data using water samples show highest number of detections across sites for Estrogen Receptor alpha (ERα) and Transthyretin (TTR), followed by Dioxin Responsive (DR) and Nrf2 oxidative stress assays. Tijuana River site in highly urbanized southern California was found to be the most toxic with 100% mortality observed in standard toxicity testing. This site also showed highest activities for five out of eight receptor activity assays. Urban land use was significantly related to number of NTA features and previous work has identified features of concern linked to ERα and DR activities. Current investigations are underway to identify additional

relationships between chemical features and receptor activities. Integration of these novel approaches into routine monitoring practices can facilitate better resource allocation and management strategies.

2.02.T-04 The Use of Mayfly Nymphs To Investigate Inconsistencies in Lines of Evidence From the Sediment Quality Triad for a Hydrocarbon Contaminated Streambed

Alexandra Switzer[1] and Ryan Prosser[1] (1)University of Guelph

The Sediment Quality Triad (SQT) is a weight-of-evidence approach that integrates sediment chemistry, sediment toxicity bioassays, and in situ biological assessments to understand potential contaminant-driven ecosystem changes. The objective of this study was to investigate inconsistencies in SQT lines of evidence (LOEs) at a spring-fed creek located near a decommissioned natural gas refinery in Alberta, Canada. At the creek, contaminants including sulfolane, diisopropanolamine, and hydrocarbons have been detected in groundwater, surface water, and/or sediments, with some at relatively high concentrations. While laboratory toxicity tests using homogenized cores of site sediments have demonstrated toxicity to several organisms, in situ evaluation of benthic invertebrate communities does not indicate any adverse effects. It is hypothesized that natural sediment deposition has provided a layer of protection for biota above more contaminated sediment. Therefore, when cores were homogenized, previously buried contaminants were re-dispersed making them more bioavailable to organisms, resulting in toxic effects. To test this hypothesis, sediment samples were collected using a hand corer from seven different locations along the stream. Where applicable, visual appearance of stratification was used to separate cores into upper and lower layers. Laboratory toxicity tests took place in glass jars containing the site sediment and overlying culture water. Mayfly (Hexagenia spp.) nymphs were added to each vessel and allowed to bury in sediments for 96 hours. After exposure, nymphs were sieved from the sediment and mobility/mortality was assessed. Variation in toxicity was observed between upper and lower layers of sediment at each sampling site and between sampling sites along the gradient of the stream. The results of this study aim to clarify previous discrepancies between SQT LOEs to provide risk assessors an enhanced understanding of the potential impacts to benthic invertebrate communities therefore allowing more informed remediation decisions.

Disclaimer/Disclosure: This research was funded through an NSERC Alliance Grant.

2.02.T-05 Ecological Risk Assessment for Nuclear Facilities: Sharing Insights From an Investigation of Sediment Toxicity to Benthic Invertebrates

George Alipanopoulos[1] (1)EGIS Group

As part of an ecological risk assessment (EcoRA) for a nuclear waste storage facility, the effects of metals and dioxins & furans (D&F) in sediment on aquatic biota were evaluated. Although emissions modelling indicated negligible contributions from the waste facility incinerator, D&F can form from combustion of conventional waste. To address uncertainty on concentrations in media from previous EcoRAs, metals and D&F were retained as contaminants of potential concern (COPCs), supported by their known occurrence, proclivity for bioaccumulation, and toxicity.

As D&F have a common mechanism of action, they are assessed using a single toxic equivalent quotient

(TEQs). Sediment collected from on-site streams in 2020 and 2025 had metal and TEQ concentrations exceeding the respective sediment screening criteria at various locations, indicating potential localized effects. To refine the risk characterization, 14-day toxicity tests were conducted with Hyalella azteca to assess survival and growth in sediment collected from 4 test locations.

Mean survival was significantly lower ($p<0.05$) than the reference sediment at one location, AC-1. To better understand the drivers of these effects, COPC concentrations, substrate composition (i.e., % gravel, sand, silt, and clay), and total organic carbon (TOC) were evaluated against survival and growth using linear regressions. No significant relationship was found between TEQ and either endpoint. Instead, copper, % sand, and % silt had strong negative relationships with survival, suggesting that substrate characteristics and legacy copper contamination is driving the reduced survival rates at AC-1.

Overall, the findings indicate that toxic effects were localized and attributable primarily to substrate properties and copper instead of D&F. This study underscores the importance of incorporating toxicity testing as an additional line of evidence in cases where risks to ecological receptors are predicted, especially when uncertainty is high and traditional EcoRA modelling tools are insufficient.

2.02.T-06 From Single Contaminant Exposure to Mixture Toxicity: Three Environmental Case Studies Illustrate When Site-Specific Chemical Mixtures Matter

Sara Nedrich[1], Shaun Roark[2], Alex Fallon[2], Jeremy Rigsby[3], Markus Hecker[4], Markus Brinkmann[4], Natacha Hogan[4], Francisco da Silva[4], Trevor Carlson[5], Brandon Armstrong[6], Claudia Walecka-Hutchison[1] and Todd Tambling[1] (1)Dow Chemical Company, (2)Jacobs, (3)FTN ASSOCIATES, (4)University of Saskatchewan, (5)Geosyntec, (6)State of Michigan, Department of Environment, Great Lakes, and Energy

While traditional regulatory frameworks rely heavily on single contaminant toxicity thresholds, chemicals in environmental systems are interdependent and present in diverse mixtures. Standard laboratory toxicity testing and modeling techniques focusing on chemical mixtures can tease apart relationships between chemicals of concern; however, it can be a complex and time intensive process. In this study, we highlight existing regulatory frameworks and available technologies to assess potential adverse effects of chemical mixtures. Three case studies will be discussed: (1) acid mine drainage from a pit mine lake, (2) genomic assisted toxicity assessment at an agricultural waste facility, and (3) neonicotinoid mixtures in a river system. Technologies discussed include metal mixture modeling, whole effluent toxicity testing (WET), EcoToxChip, cellular toxicity testing, and polar organic chemical integrative samplers (POCIS). These case studies and technologies show that chemical mixture toxicity can be evaluated effectively on a site-specific basis. Regulatory flexibility to adapt applied technologies in lieu of single contaminant criteria may result in more effective environmental management, especially where large-scale remediation or reclamation may be required.

Assessing Toxicity in Water and Aquatic Sediments

2.02.P-Th248 Physiological, Behavioral, and Reproductive Effects of Tetracycline Exposure on Blackworms (Lumbriculus variegatus)

Alyssya Raczkowski[1], Risa Cohen[1] and Rocío Pérez[2] (1)Georgia Southern University, Department of Biology,

(2)Georgia Southern University, Department of Biochemistry, Chemistry, and Physics

The widespread use of antibiotics in human medicine and livestock production contaminates aquatic environments through wastewater discharge and agricultural runoff. Tetracycline, a low-cost and broad-spectrum antibiotic, accumulates in sediment, posing risks to ecologically important benthic organisms. Blackworms (Lumbriculus variegatus) are essential in sediment nutrient cycling and serve as a food source for higher trophic levels. While blackworms are an important indicator species for contaminants, their physiological and behavioral responses to tetracycline remain largely unknown. This study investigated how tetracycline affects blackworm tissue accumulation, physiology, behavior, and reproduction. Blackworms were exposed to one of four tetracycline concentrations (0, 10, 100, or 1000 μg L^{-1}) for 28 days (n=8). Experimental units contained 100 mg of blackworm biomass, 250 mL of treatment solution, and 50 g of sediment substrate and were continuously aerated under a 16L:8D photoperiod. Blackworms were fed twice weekly. To maintain exposure concentrations and minimize waste buildup, treatment solutions were renewed daily and water quality parameters (temperature, conductivity, pH, dissolved oxygen) were monitored. At the end of the experiment, tetracycline accumulation in worm tissue was quantified using LC-MS. Physiological endpoints indicative of oxidative stress were evaluated by measuring catalase activity and lipid peroxidation. These biomarkers were selected because antibiotic exposure increased catalase activity in response to reactive oxygen species production and induced lipid peroxidation through oxidative damage to cell membranes in other aquatic invertebrates. Changes in biomass, asexual reproduction by fragmentation, and sediment avoidance were evaluated to determine how tetracycline influences overall organism performance. It was predicted that with increasing ambient tetracycline concentration, tissue tetracycline concentration, catalase activity, lipid peroxidation, fragmentation and sediment avoidance should increase. In contrast, biomass should decrease with increasing tetracycline concentration. These results will provide insight into the ecological consequences of antibiotic contamination and the potential for tetracycline transfer through aquatic food webs.

2.02.P-Th249 Tyre Wear Particle Leachates Alter Neurotransmission, Stress Response, and Energy Metabolism in Physella acuta

Ahlam Mohamed-Benhamu[1], Victor Carrasco Navarro[2] and Jose-Luis Martinez-Guitarte[1] (1)National University of Distance Education (UNED), (2)University of Eastern Finland

Tyre rubber particles (TRPs) are an emerging source of freshwater pollution due to the release of complex mixtures of chemical additives. In a previous study, we evaluated the behavioural effects of TRP leachates on the freshwater gastropod Physella acuta after 24 h and 7 d of exposure. Adult snails exposed to leachates obtained from a 10 g/L suspension of new TRPs at concentrations ranging from 0 to 25% showed behavioural alterations before and after exposure to predator cues from crayfish (Astacus astacus). Exposure to high leachate concentrations (25%) reduced snail activity and impaired predator avoidance behaviour, while lower concentrations (5% and 15%) induced slight increases in activity.

In the present study, the molecular mechanisms underlying these behavioural effects were investigated by analysing the expression of genes related to neurotransmission, stress response, calcium signalling, and energy metabolism. Molecular analyses revealed significant transcriptional alterations potentially associated with the observed behavioural responses. After 24h of exposure, genes involved in neurotransmission (DRD1, AChE, and SLC6A2) were generally downregulated at higher concentrations, suggesting acute neurotoxic effects. After

7d, some genes, including ADORA2B and DRD1, showed increased expression, indicating possible compensatory responses during prolonged exposure.

The stress-response gene Hsp90 exhibited the strongest transcriptional changes, with downregulation after acute exposure and increased expression at intermediate concentrations after 7d. Alterations were also detected in RYR and PYGL, suggesting disruptions in calcium signalling and energy metabolism.

Overall, these results demonstrate that TRP leachates induce both behavioural and molecular alterations in P. acuta, highlighting the ecological risks posed by tyre-derived contaminants in freshwater ecosystems.

Disclaimer/Disclosure: This work was supported by the Plan Nacional de Investigación Científica, Desarrollo e Innovación Tecnológica (Spain) and European Funds. (Project reference: PID2022-136669OB-100). AMB is a recipient of a fellowship (PRE2022-000781).

2.02.P-Th250 Evaluating Locomotor Behavior, Viability, and Bioaccumulation of the Exposed Hyallela Azteca Amphipod in Lead and Cadmium Contaminated Sediments

Garrett Driscoll[1], Joey Gasink[1], Tyler Frankel[1] and Leanna Giancarlo[1] (1)University of Mary Washington

Aquatic trace metal toxicity is a known and widespread issue due to the several anthropogenic and natural sources of contamination into waterways. Trace metal contamination is known to possess carcinogenic, teratogenic, and reproductive effects which exert negative pressures on individual, population, and ecosystem health. Sediments concentrate trace metals, potentially leading to increased effects on benthic aquatic organisms. While previous work examining the impacts of trace metals on aquatic invertebrates has primarily focused on freshwater nektonic species, relatively few studies have examined sublethal effects on behavior in sediment-dwelling organisms. As such, this study assessed the effects of cadmium (Cd - 0, 2, 4, 6, 8 and 10 ppm) and lead (Pb - 0, 5, 25, 50, 100 ppm) exposure on the survival and locomotor behavior of the benthic invertebrate Hyalella azteca using spiked sediments. Individual 100 mL acid-washed glass jars were prepared utilizing 35 grams of a given Cd or Pb enriched dried sediment inundated with 50 mL of synthetic freshwater. Individual H. azteca were exposed for 9 days at 21°C using static replacement (100% change every 3 days). Individuals were fed a 1:1 diatom to fish flake feed solution (25µL) after each water change. Mortality was monitored every 3 days. After 9d, surviving individuals were placed into a custom behavior chamber and activity was recorded for 3 min. Noldus Ethovision XT 17 was then used to assess differences in distance (cm), velocity (cm/min), acceleration (cm/min2), meander (deg/min), and mobility (%). After exposure, whole tissues were dried, digested, and analyzed using ICP-OES for concentrations of Cd and Pb to calculate bioaccumulation. While this study is still ongoing, we expect to find negative dose-dependent behavioral and locomotor impacts on H. azteca, with Cd causing more harmful effects due to its reportedly higher toxicity. We expect to find elevated cadmium and lead exposure is linked with higher bioaccumulation and disrupted locomotor behavior in H. azteca. The results of this study will provide a deeper understanding of how trace metal exposure may alter the behavior and survival of benthic organisms within polluted ecosystems.

2.02.P-Th251 Lifespan and Multigenerational Health Outcomes for Zebrafish (Danio rerio) Reared in Detroit River Surface Water

Danielle Meyer[1], Jessica Phillips[2], Alex Haimbaugh[1], Mackenzie Connell[2], Bridget Baker[1] and Tracie Baker[1] (1)University of Florida, (2)Wayne State University

The Detroit River, a Great Lakes waterway situated between southeast Michigan and southwest Ontario, serves as a critical international transportation route, biodiversity corridor, cultural and recreational hub, and drinking water source for over 4 million people. Despite decades of restoration and remediation in this ecoregion to address a legacy of heavy industrialization and urban run-off, surface water sampling from the raw water intake of a Detroit River drinking water treatment plant (DWTP) from January to December 2020 revealed a contaminant mixture predominantly consisting of pesticides (e.g., atrazine and metolachlor) and pharmaceuticals (e.g., metformin and salicylic acid) at ng/L (parts per trillion) levels. Previous research using a zebrafish (Danio rerio) model showed that developmental exposure to individual contaminants can lead to reduced fertility, increased mortality, morphological abnormalities, and delayed puberty. Thus, we hypothesized that lifespan exposure to the contaminants found in Detroit River surface water would also induce health effects in exposed zebrafish and their offspring. We raised two groups of zebrafish in either reverse osmosis water buffered with salts (controls) or surface water from the raw water intake of a Detroit River DWTP (exposed). Next, we examined the fertilization rate and fecundity of exposed F0 fish, as well as mortality, morphological abnormalities and neurobehavior in their F1 larval offspring. Exposed fish produced a higher percentage of non-viable eggs (27.4% vs 18.5% in controls; $p<0.001$), while a larger percentage of their F1 larval offspring presented with uninflated swim bladders (19.3% vs 11.4% in controls; $p<0.05$). We also isolated RNA from F0 adult brain, liver, and gonad and pooled F1 larval samples to perform transcriptomic analysis using QuantSeq 3' mRNA sequencing, reporting differentially expressed genes (DEGs) at log2FC = |0.75| and p-value < 0.05. F1 larval offspring were most profoundly impacted, reporting 2199 DEGs in pathways including mitochondrial dysfunction, sirtuin signaling, oxidative phosphorylation, estrogen receptor signaling, and synaptogenesis signaling. These findings reveal generational and life stage-specific impacts of exposure to environmental contaminant mixtures, highlighting the relevance of zebrafish as a sentinel organism for waterbody contamination.

2.02.P-Th252 Fate and Effects of Quaternary Ammonium Compounds in Fresh Waters

Mallory Christenson[1], Lauren Timlick[2], Jermey Marshall[3], Jose Luis Rodriguez Gil[2], Vince Palace[2], Karen Kidd[4], Markus Hecker[1], Natacha Hogan[1] and Markus Brinkmann[1] (1)Centre of Toxicology, University of Saskatchewan, (2)International Institute for Sustainable Development (IISD), (3)Toxicology Centre - University of Saskatchewan, (4)McMaster University

The increased use of disinfectant compounds in cleaning and personal care products since the SARS-CoV-2 pandemic has led to the widespread presence of disinfectants. Common disinfectants included Lysol and Clorox disinfectant wipes and sprays, many of which contained quaternary ammonium compounds (QACs). These compounds, including the sub-category alkyldimethylbenzylammonium chloride (ADBACs) were released into aquatic environments through wastewater effluents. Although laboratory studies have shown that this group of antimicrobials is toxic to many species that support aquatic food webs, their fate, persistence, and ecosystem effects in surface waters and sediments are relatively limited. To address this gap, we conducted a whole lake experiment at the Experimental Lakes Area (ELA) to assess the fate and ecological effects of C10-18 ADBACs

in a freshwater system. Water and sediment samples are being collected and analyzed using ultra-high-performance liquid chromatography to quantify ADBAC concentrations and characterize their distribution among environmental compartments. Data collection and analysis are currently ongoing. Although present in both compartments, ADBACs tend to be in higher concentrations in the water column. Further, ADBACs have demonstrated a higher concentration at the air-water interface rather than in deeper waters due to both polar and nonpolar properties. This work will contribute to the broader understanding of the risks associated with emerging disinfectants following the increased use throughout the pandemic.

2.02.P-Th253 Influence of Pit Dewatering on Metal Bioavailability for Salmonids in Gaspésie

Nabil Akrache[1], Wijdane Limouni[1], Claude Fortin[1] and Patrice Couture[1] (1)National Institute for Scientific Research (INRS)

Copper is a key metal in the currently ongoing energy transition, widely used in electric vehicles, wind turbines, and smart power grids. In this context, the Mines Gaspé deposit represents a strategic resource for both Quebec and Canada. Operated from 1955 to 1999 and subsequently restored, this open pit mine located in Murdochville (QC) was acquired in 2023 by Osisko Metals. Its reopening requires the dewatering of the main pit, which has been filled with water since mining operations ceased. This water is characterized by elevated concentrations of some metals like copper and will be treated to reduce metal concentrations before being released. The site is located upstream of the York River watershed, an ecologically important system, particularly for salmonids. The population of this anadromous species is declining in many watersheds and is highly sensitive to metal contaminants, which can accumulate in tissues and impair essential biological functions.

The objective of the project is to assess the potential impacts of pit dewatering on metal bioavailability and bioaccumulation for salmonids [WL1.1]and on the physicochemical conditions of salmonid habitat in the York River.

To this end, fish and water from 12 stations distributed along the river, including reference sites and sites potentially influenced by metal inputs, were sampled to provide background data before dewatering. Sampling will be repeated during the dewatering phase to ensure that the operation does not impact fish and its habitat. Water samples will be analyzed in the laboratory using three approaches: dissolved metals, total extractable metals using ICP-AES and ICP-MS, and dissolved anions using ion chromatography. Fish tissues will also be analyzed for a suite of metals to establish baseline metal contamination and monitor its evolution during dewatering.

Preliminary results show higher dissolved metal concentrations at sites influenced by pit water compared to reference sites. These results are associated with overflow events and do not yet reflect the effects of dewatering operations. This study will improve the understanding of mine pit dewatering impacts on water quality and metal bioaccumulation in salmonids and will support the development of biomonitoring tools for future mining operations. The results provide baseline environmental conditions prior to the official dewatering of the pit, allowing assessment of potential changes during dewatering and subsequent operations.

Disclaimer/Disclosure: This project is funded through the NSERC Alliance Advantage program in partnership with Osisko Metals and the Atlantic Salmon Conservation Foundation (FCSA).

2.02.P-Th254 Evaluation of Total Mercury, Zinc, Lead, and Arsenic Concentration in Fish Fillets, Water and Sediments From Dunlap Lake in Edwardsville Illinois

Christopher Theodorakis[1], Chima Okalanwa[1] and Zhiqing Lin[2] (1)Southern Illinois University Edwardsville, (2)Soutern Illinois University Edwardsville

Aquatic ecosystems and their constituent biota are often environmental compartments with the metal contamination. For example, preliminary studies have found that heavy metal contamination is a concern in Edwardsville, IL. In order to further explore potential risks from heavy metals to human health and the environment, total mercury, lead, zinc, and arsenic concentrations were determined in fish fillets, water, and sediments collected from Dunlap Lake, a private lake in Edwardsville Illinois. The heavy metals were measured using inductively-coupled plasma mass-spectrometry. The mean zinc concentration was highest in redear sunfish (Lepomis microlophus) and lowest in largemouth bass (Micropterus salmoides). Average lead (Pb) concentrations in the fish fillets were highest in yellow bullhead (Ameiurus natalis). Mean total mercury in fillets ranged from 0.17 mg/kg (Channel catfish, Ictalurus punctatus) to 0.68 mg/kg (largemouth bass, Micropterus salmoides). Mean total arsenic concentration in fish fillets was highest in common carp (2.56 mg/kg). There were statistically-significant differences between the fish species for Hg and no significant difference among species for Zn and Pb. The average heavy metal (Pb, Hg and As) concentrations in the water were 4.62, 1.34 and 5.51 µg/L respectively and zinc was below the detection limit (<0.1ppb). In the sediment, the average heavy metal (Zn, Pb, Hg, and As) concentrations increased in the order Zn > Pb > As > Hg. Aqueous lead concentration may be above the National Ambient Water Quality Criteria (NAWQC) for aquatic life, and arsenic exceeded NAWQC for human concerns effect. Lead in fillets were below WHO action limits based on wet weight. The concentrations of Hg in largemouth bass were below the FDA action limits, but further monitoring is warranted to ensure the lake safety with respect to metal concentrations. The sediment concentrations of zinc exceeded Severe Effects Levels.

2.02.P-Th255 Reducing Variability in Vitellogenin Measurements in the Fish Short-Term Reproduction Assay: Does Fish Age and Size Matter?

Alan Jones[1], Paul Thellman[2] and Lennart Weltje[2] (1)BASF Agricultural Solutions, (2)BASF Agricultural Solutions Deutschland

Variability in fish vitellogenin (VTG) measurements is a common issue complicating interpretation of endocrine studies like the Fish Short Term Reproduction Assay (FSTRA, OECD TG 229[LW2.1]; OCSPP 890.1350). Since there is substantial variability in VTG measurements among fish within the same replicate, it is desirable to be able to provide some type of normalization within treatments and replicates to reduce the inherent variability. Here, we hypothesize that fish age, size, the amount of blood sampled, and the tissue analyzed for VTG may all impact the variability of these measurements.

To examine this hypothesis, we tested two cohorts of fathead minnows (each with three groups) – one cohort of the same age (5.1 – 5.4 months), and the second three different age[TC3.1]s[LW4.1][PT4.2] (4.0 – 6.7 months). Each group of fish was established as FSTRA-like breeding groups with two males and four females (with four replicates) and were allowed to spawn for 14 days under control conditions. At the end of the breeding period, all fish were sacrificed and data for weight, gonadosomatic index (GSI), blood volume, plasma volume, plasma VTG concentration and tail homogenate VTG concentration were collected from the females. Initial results

indicate that there is no relationship between GSI and VTG concentrations, and interestingly, increasing tail weight appears to be diluting VTG concentrations when analyzed as a tail homogenate.

2.02.P-Th256 Case Studies From the Lubricants Industry of Some of the Challenges and Solutions for Conducting Aquatic Toxicity Testing on Metal Carboxylate Salts

Rhiannon Smith[1], Sylwia Kosmala-Grzechnik[1] and Lucy Kennelly[1] (1)wca environment Ltd.

Metal carboxylate salts are key compounds used by the lubricants industry to control the viscosity of greases. These include lithium, calcium and aluminium as the metal ions and mono- and di-carboxylic acids as the acid components. The substances have been registered under regulatory programs which require the submission of information on long-term toxicity to aquatic organisms. However, these substances are considered difficult to test, including having low solubility, surface activity and/or being UVCBs (substances of unknown, variable or complex composition or of biological origin). This presentation gives a case study of some of the challenges we have encountered in testing these types of substances and the solutions we have applied to address these.
There have been significant analytical challenges due to the lack of analytical method for the whole salt and the need to analyse the metal and organic component separately. The metal ions are often included as nutrients in the test media (e.g. Li in M7 media used for Daphnia studies) or are present at high background concentrations (e.g. Ca), so the metal in the test solution that is derived from the test item can be difficult to distinguish, especially at low test item concentrations. The acid components of the substances often rapidly degrade in the test system, so the concentrations are below the limit of detection (LOD) of the analytical method. Testing at low concentrations means that the organic components are often below the LOD of Total Organic Carbon (TOC) analytical method, as a surrogate for compound-specific analysis. We are currently reviewing options to address this in the planned long-term aquatic toxicity tests on these substances.
These analytical challenges are all exacerbated by the low water solubility of the salts, as even when testing at the limit of saturation, the concentrations in test media are very low. Solubility challenges have also been encountered in other test systems, such as acquiring dosable solutions in some in vitro test systems where the substances were insoluble in all standard vehicles for the test system. The in vitro issues were encountered during human health genotoxicity testing; however, it is anticipated that similar issues will occur for environmental in vitro tests that may be conducted in the future, such as those expected to be introduced for endocrine disruption assessment.

2.02.P-Th257 Using RTgill-W1 Cells To Assess Environmental Water Samples Directly: Development and Application of a Transwell Insert System

Sophie Emberley-Korkmaz[1] and Niladri Basu[1] (1)McGill University

Fish cell lines are increasingly being pursued as an alternative approach in environmental monitoring strategies due to their ability to rapidly screen sites and provide relevant biological data. Specifically, the rainbow trout gill cell line (RTgill-W1) was approved by the International Organization of Standardization (ISO) to measure the cytotoxicity of water and effluent samples (ISO 21115:2019). However, the assay requires the addition of salts to water samples to maintain osmotic pressure, minimizing its use to directly study unadulterated freshwater. Added salts could interact with chemicals in real-world samples, modifying the in vitro response. To address this gap, we hypothesize that a transwell insert system with assay modifications will allow direct

exposure of real-world water samples to RTgill-W1 cells without needing salt supplementation, enhancing ecological relevance and applicability. Aim 1 established the technical design of the approach using three measurements: 1) three cell viability endpoints, 2) transepithelial electrical resistance (TEER) readings, and 3) immunocytochemical staining with confocal microscopy to visualize cells. RTgill-W1 cells were exposed to artificial freshwater samples, and 100% cell viability across the three endpoints was maintained, indicating the system could withstand direct water application. TEER values and microscopy also confirmed this. Aim 2 applied this approach to real-world water samples from a suspected contaminated site within 100 km of Montreal. Water samples were analyzed for 7 heavy metals and 69 organic contaminants, with results compared to the Canadian Council of Ministers of the Environment (CCME) water quality guidelines for the protection of aquatic life. Aim 3 is underway, exposing RTgill-W1 cells to these site water samples following the transwell insert protocol and the ISO 21115:2019 protocol. Cytotoxicity results will be compared between the two approaches (i.e., chemical measures of the water vs. cytotoxicity responses) to assess if the transwell insert system improves sensitivity. Overall, this work hopes to present modifications to ISO 21115:2019 that allow RTgill-W1 cells to be exposed directly to unadjusted water samples, while also providing insights into how these in vitro toxicity results can be used alongside contaminant information to better characterize water health.

2.02.P-Th258 Development of a Bioanalytical Screening System for the Toxicological Characterization of Remediation Options of Contaminated Soils

Parker Jones[1], Blake Hunnie[1], Catherine Roberts[1], Juleanne Flores[1], Julie Borsa[1], Todd Tambling[2], Claudia Walecka-Hutchison[2], Francisco Da Silva[1], Markus Brinkmann[1], Natacha Hogan[1], Markus Hecker[1] and Sara Nedrich[2] (1)University of Saskatchewan, (2)Dow Chemical Company, Midland, MI, USA

There are many contaminated sites across Canada that may pose potential toxicological risks to human health and the environment. These sites often contain complex mixtures of chemicals, making it difficult to objectively characterize hazard, which is a critical step in developing effective soil remediation approaches. This study aims to establish a bioanalytical toolbox to assess site-specific hazard comprising of cell-based in vitro and early-life stage fish bioassays to support the in-depth characterization of sites contaminated with complex chemical mixtures. Specifically, soils from an upland site in western Canada contaminated with a phenoxyacid herbicide mixture were analyzed using rainbow trout (Oncorhynchus mykiss) gill, liver and gut cell lines (RTgill-W1, RTL-W1, RTgut-GC) and rainbow trout alevins. During the initial baseline cytotoxicity testing, EC50 values were obtained for the in vitro work and were used to compare sensitivity between the target organs. RTL-W1 cells had an EC50 value of 21.30 mg/mL SEQ (sediment equivalent), while the RTgill-W1 cells had an EC50 value of 36.94 mg/mL SEQ, indicating a higher sensitivity to the soil extract in the RTL-W1 cell line. Preliminary results from the early-life stage rainbow trout exposures demonstrated significant mortalities at concentrations greater than 4 mg/L SEQ. Mechanistic investigations using focused transcriptomics EcoToxChip arrays found many important gene pathways in rainbow trout alevins were dysregulated, including genes related to pathways such as cell signaling, neurotransmission, transcription and cell death/proliferation. However, since the tested soils were from an upland location, the exposure pathway is incomplete, and no impacts to aquatic life are anticipated at the site. Overall, this work aims to provide a thorough understanding of the hazard potential of contaminated soils at the site of concern and will inform development of an effective site-specific remediation strategy.

2.02.P-Th259 Bioassay With Allium cepa for the Evaluation of the Toxicity in Coastal Aquatic Environments

Gabriela Rodriguez Fuentes[1], Jonathan Uribe López[2] and Elsa Norena-Barroso[1] (1)National Autonomous University of Mexico (UNAM), (2)National Autonomous University of Mexico

The Yucatan Peninsula's karst aquifer system is facing increasing pressure from contamination, as it serves as the primary freshwater source for domestic and economic activities and receives wastewater and surface leachates. This study assessed water quality and toxicity effects in the coastal areas of Sisal, Yucatan, Mexico, using the Allium cepa bioassay. Twenty-eight water samples were collected from marine zones, groundwater springs, and marshes in November 2021. Solid-phase extraction was used to concentrate organic contaminants for the analysis of 20 organochlorine pesticides, Chlorpyrifos, and 16 polycyclic aromatic hydrocarbons (PAHs). The bioassay measured cytotoxic and genotoxic effects by evaluating the mitotic index, nuclear abnormalities, and root growth. Results showed significant differences between controls and coastal water extracts, with pairwise tests revealing variations between groundwater springs and marsh samples. Contamination analysis found naphthalene in all samples, with total PAH levels reaching 14.06 ng/L at harbor sites involved in hydrocarbon activities, including engine transportation and vessel painting. Eleven organochlorine pesticides were not detected, while α-HCH, β+γ-HCH, and Chlorpyrifos appeared at the highest concentrations, especially in marsh sites. Multiple regression analysis revealed a significant relationship between the mitotic index and the concentrations of fluoranthene, pyrene, benzo[a]pyrene, and dibenzo[a,h]perylene. The study confirms the vulnerability of coastal aquatic systems to contamination from inland sources and highlights the effectiveness of the Allium cepa bioassay in detecting relevant toxicity levels. These findings underscore the pressing need for improved water resource management and monitoring to safeguard this vital aquifer system, which supports local communities and regional tourism.

2.02.P-Th260 Can a Zerovalent Iron-Based Thin Reactive Amendment and Protective Cap (TRaP) Decrease Toxicity and Bioaccumulation of Arsenic and Mercury in Field Deployed Hyalella azteca?

Heidi Gavel[1], Emily Chapman[1], Kaitlyn Kerr[1], Logan Phillips[1], Bradley Knockwood[1], Enobong Udoh[1], Samuel Sequeira[1], David Lewis[1], Liam Hill[1], Lauren MacDonald[1] and Linda Campbell[1] (1)Saint Mary's University

Legacy goldmining in Nova Scotia (NS) has resulted in the contamination of wetlands, ponds, rivers, and other waterbodies with arsenic (As) and mercury (Hg), often exceeding local guidelines for aquatic health. Laboratory testing has shown that aquatic invertebrates exposed to legacy goldmine tailings-impacted sediment and water display increases in oxidative stress, metal(loid) bioaccumulation, behavioural changes, and decreased survival. Here, we examine if a zero-valent-iron based Thin Reactive Amendment and Protective Capping (TRaP) can decrease toxicity and bioaccumulation of As and Hg in laboratory reared Hyalella azteca. Adult H. azteca (2,016 total) were exposed to untreated and TRaP treated contaminated sediment and water in triplicate within mesocosm enclosures at a contaminated wetland and reference site in NS. After seven days, H. azteca were retrieved, survival was assessed, and tissue samples were collected for Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS). In addition, wild amphipods were collected from the sites for bioaccumulation comparisons. At test end, H. azteca in TRaP treated mesocosms had a significantly ($p<0.001$) higher mean survival (69%) than H. azteca in untreated mesocosms (0.6%). Due to the low survival rate in untreated mesocosms, H. azteca tissue was not analyzed for As and Hg concentrations in most of these

replicates. However, H. azteca exposed to TRaP treated contaminated sediment had lower accumulated As than wild caught amphipods from the tailings-impacted site. Likewise, dissolved As and As(III) in surface water was much lower in TRaP treated mesocosms than untreated mesocosms, similar to background values. Methylmercury (MeHg) concentrations in surface water were significantly ($p<0.01$) lower in TRaP treated mesocosms than those in untreated mesocosms. This research demonstrates that TRaP may be a useful remediation strategy for legacy goldmine tailings-impacted wetlands. Additional research focusing on sub-lethal and reproductive endpoints should be conducted to further assess the effectiveness and safety of this treatment for aquatic invertebrates.

2.02.P-Th261 Niclosamide Enhances the Toxicity of the Lampricide TFM by Inhibiting Its Hepatic Metabolism in Sea Lamprey and Rainbow Trout: Implications for Sea Lamprey Control in the Great Lakes

Dejana Mitrovic[1], Leslie Bragg[1], Mark Servos[1] and Michael Wilkie[2] (1)University of Waterloo, (2)Wilfrid Laurier University

To protect fisheries, the lampricide TFM (3-trifluoromethyl-4'-nitrophenol) is used to control populations of invasive, blood-sucking sea lamprey (Petromyzon marinus) in the Great Lakes. Sea lamprey are more sensitive to TFM than non-target fishes, such as rainbow trout (Oncorhynchus mykiss), due to their limited ability to detoxify it. Applied to streams infested with larval sea lamprey, TFM is often co-applied with smaller amounts of niclosamide (0.5–2.0%), which is also a well-known molluscicide. In the presence of niclosamide, the TFM concentration required to maintain its effectiveness is reduced by up to 40%. Both chemicals are biotransformed via the Phase II metabolic pathway, using uridine diphosphate glucuronosyltransferase (UDPGT) and phenol sulphotransferase enzymes, which generate less toxic, more easily excreted metabolites. Both lampricides also exert their toxicity by disrupting oxidative phosphorylation and mitochondrial ATP production. However, the mechanism(s) of the interaction between TFM and niclosamide (Nic) are not completely resolved. Greater TFM toxicity in the presence of niclosamide is associated with increased TFM accumulation in tissues. Using LC-MS/MS, TFM was quantified in the liver and muscle of sea lamprey and in the liver, brain and muscle of rainbow trout exposed to the same concentration of TFM, with or without niclosamide (1%). There was much greater TFM accumulation in the muscle of sea lamprey in the presence of niclosamide than in the TFM-only treatment, without a corresponding increase in liver concentrations, suggesting impaired hepatic metabolism. In rainbow trout, significant increases in TFM accumulation were observed in liver and brain tissue, without significant increases in muscle accumulation, suggesting impairment of TFM metabolism due to competitive inhibition of Phase II metabolic enzymes, UDPGT and phenol sulphotransferase. Therefore, the tissue distributions and patterns of bioaccumulation differed between sea lamprey and rainbow trout, indicating species-specific differences in TFM mechanisms of toxicity and the effects of niclosamide addition. These results will enable more precise tailoring of lampricide treatments to maximize efficiency, reduce costs, and minimize non-target effects.

2.02.P-Th262 Influence of Water Flow on Physiological Responses to Microplastic Exposure in Daphnia magna

Sejal Dave[1], Shooka Karimpour[1] and Raymond Kwong[1] (1)York University

Microplastics (MPs) are widespread contaminants in freshwater ecosystems and are ingested by aquatic

organisms such as Daphnia magna. Daphnia are freshwater zooplankton that serve as an important food source for many aquatic species and are widely used as model organisms for assessing contaminant effects. Most studies examining MP toxicity in aquatic animals are conducted under static (non-flowing) laboratory conditions, despite many freshwater organisms inhabiting dynamic environments where water movement may influence contaminant exposure and biological responses. This study examined whether water flow alters MP bioaccumulation and physiological responses in Daphnia. For 23 hours, Daphnia were exposed to fluorescent polyethylene MPs (45-53 μm) at 10 or 60 mg/L under static or flow (2 cm/s) conditions in a controlled swim tunnel system. Following exposure, MP bioaccumulation, oxygen consumption (MO2), and reactive oxygen species (ROS) were quantified. RNA was also extracted for transcriptomic analysis. No statistically significant differences in MP bioaccumulation were observed. In contrast, physiological responses were influenced by exposure conditions, with the combined MP and flow treatment consistently producing the highest MO2 and ROS levels. Across all treatments, ROS responses were higher at 10 mg/L than at 60 mg/L. These results indicate that water flow may increase energetic demand and oxidative stress during MP exposure, even when MP bioaccumulation remains unchanged. The greater ROS response at 10 mg/L than at 60 mg/L may indicate suppression of antioxidant defence mechanisms at higher MP concentrations. Ongoing transcriptomic analyses will identify the molecular pathways associated with these physiological responses, particularly genes involved in stress regulation, metabolism, and detoxification. These findings demonstrate that flow can influence the physiological consequences of MP exposure independently of bioaccumulation, emphasizing the importance of incorporating realistic hydrodynamic conditions into freshwater ecotoxicology studies.

2.02.P-Th263 Microplastics Toxicity and Accumulation in Planorbella pilsbryi and Tubifex tubifex

Quinn Allamby[1], Karen Kidd[1] and Ryan Prosser[2] (1)McMaster University, (2)University of Guelph

Microplastics (MPs: <5 mm) are increasingly documented in freshwater sediments, yet their impacts on benthic macroinvertebrates, which are crucial components of freshwater ecosystems, are not well characterized. This study investigated the effects of three MP types (6 and 45 μm polystyrene microbeads, and 100 μm polyethylene terephthalate microfibers) on two freshwater benthic macroinvertebrates, Tubifex tubifex and Planorbella pilsbryi, across five environmentally relevant concentrations (0, 0.1, 1, 10, 100, and 1000 MPs/g sediment or MPs/mL water). Both pristine and microbially colonized MPs were used to examine impacts on mortality, reproduction, MPs accumulation, and whole-body microbiomes. Reproduction was quantified by counting eggs and/or juveniles. Microbial communities were characterized via 16S rRNA gene sequencing targeting the V3–V4 regions. MPs accumulation was assessed post-exposure, with a depuration period to evaluate excretion capacity. No significant changes in survival or reproduction were observed for either species. While Tubifex tubifex did not show notable MPs ingestion, Planorbella pilsbryi accumulated microbeads in a concentration-dependent manner, but most were excreted following gut clearance. No significant microfiber accumulation was reported, but large quantities were present in Planorbella pilsbryi fecal casts. Both pristine and biofouled MPs significantly altered microbial diversity and community structure in Tubifex tubifex and Planorbella pilsbryi, indicating that MPs exposure may lead to microbiome disruption. Despite the absence of significant toxicity, alterations in host-associated microbiota and significant MPs ingestion in some species indicate key ecological risks, including trophic transfer and dysbiosis.

2.02.P-Th264 Developmental and Molecular Effects of Synthetic Musks and Plasticizers in Zebrafish Embryos and Larvae

Seunghyun Kim[1] and Kyunghee Ji[1] (1)Yong In University

Diisobutyl phthalate (DiBP) is a widely used phthalate plasticizer, whereas diisobutyl adipate (DiBA) is increasingly used as a non-phthalate alternative. Tonalide (AHTN) and musk ketone (MK) are synthetic musk fragrances commonly detected in consumer products and aquatic environments. However, information regarding their developmental toxicity and underlying molecular responses remains limited.
Zebrafish embryos were exposed to AHTN and MK (0.03–300 μg/L) or DiBP and DiBA (0.05–500 μg/L) for 96 h following OECD Test Guideline 236. Developmental endpoints were assessed, and expression of growth hormone/insulin-like growth factor (GH/IGF) axis-related genes was analyzed. Vascular development- and oxidative stress-related genes were additionally evaluated in DiBP- and DiBA-exposed larvae.
Body length was significantly reduced following exposure to AHTN (300 μg/L), DiBP (50 μg/L), and DiBA (500 μg/L). DiBP induced the strongest developmental toxicity, increasing coagulation, reducing survival, and delaying hatching. In contrast, MK did not significantly affect developmental endpoints. At the molecular level, AHTN decreased gh1 and ghra expression, while DiBP increased nkx2.5 and decreased ghra expression, indicating growth- and cardiac development-related responses. DiBA significantly reduced vegfaa expression, suggesting disruption of vascular development signaling.
Overall, AHTN, DiBP, and DiBA adversely affected early growth and development in zebrafish, whereas MK showed limited toxicity under the tested conditions. Alterations in GH/IGF axis-related genes indicate growth-associated molecular responses, while reduced vegfaa expression following DiBA exposure suggests potential perturbation of angiogenic pathways. These findings highlight the need for further mechanistic studies on the developmental and vascular effects of alternative plasticizers and fragrance compounds.

Disclaimer/Disclosure: This study was supported by the Chemical Safety Management Specialized Graduate School Program funded by the Ministry of Climate, Energy and Environment of the Republic of Korea and administered by the Korea Environment Conservation Agency (KECA) in 2026.

2.02.P-Th265 Thinking Differently: Redesign of a Long-Term Receiving Environment Monitoring Program in a Large Tidal River Following Installation of an Upgraded WWTP Outfall in British Columbia

Connor Pettem[1], Elaine Irving[1], Michael Hall[2] and Denise Vieira[2] (1)WSP Canada Inc., (2)Metro Vancouver

The Lower Fraser River is the receiving environment for secondary treated effluent from the Annacis Island Wastewater Treatment Plant (AIWWTP). Environmental monitoring in the Fraser River has been conducted for more than two decades by Metro Vancouver in collaboration with consultants, agencies, and academic partners. Water quality monitoring has been completed annually with sediment and biota (fish) monitoring completed on a five-year cycle and supplementary monitoring as required. WSP conducted annual water quality monitoring for four years and individual sediment quality, toxicity, and benthic invertebrate investigations specific to the new outfall before being contracted to review the existing program and develop a receiving environment and aquatic effects monitoring program (REAEMP) to meet regulatory requirements for a new hydraulically upgraded outfall. Previous monitoring approaches, methods, and data were reviewed, with the goal of developing an effective approach for this complex receiving environment.

Monitoring in large, tidally influenced rivers with watersheds and sediment loads flowing through industrial urban centers is complex. Key challenges include: spatial and temporal variability (both natural and human-related), regional influences (e.g., downstream sediment transport to the river delta), hydrological and tidal influences affecting the presence and predictability of WWTP inputs (e.g., fine sediments in effluent discharge). While water quality monitoring is reliably completed at near (initial dilution zone) and far field sites, sediment monitoring in the vicinity of the outfall is challenged by lack of depositional areas and the movement of effluent-derived particles and fish-based endpoints are constrained by capture success and site fidelity.

WSP developed an alternative monitoring approach to evaluate the potential effects of the AIWWTP discharge in the lower Fraser River. WSP's approach includes a tiered, adaptive monitoring framework for the REAEMP that integrates long-term trend analysis of annual water quality data, outfall plume characterization, and targeted, question-driven biological investigations. This poster presents the framework, demonstrating how legacy monitoring data can be leveraged to improve program efficiency, strengthen source-linkage evaluation, and focus monitoring effort in complex, dynamic river systems.

2.02.P-Th266 Investigating the Accumulation, Trophic Transfer, and Effects of Microcystin in a Central Tennessee River

Sabrina McKenna[1], Muny Chet[2], Andrew Hetrick[1] and Frank Bailey[1] (1)Middle Tennessee State University, (2)No Affiliation

Cyanobacterial harmful algal blooms (cHABs) occur when cyanobacteria, or blue-green algae, overpopulate a waterbody. These blooms are often caused by a combination of nutrients, temperature, light, and water stability and can result in the degradation of aquatic systems from toxin production as well as taste and odor. The most common cyanobacterium responsible for these blooms is Microcystis sp. which produces the hepatotoxin, microcystin. The objectives of this study were to 1) assess the bioaccumulation, aquatic to terrestrial trophic transfer, and effects of microcystin, and 2) investigate correlations between Microcystis, microcystin, and water quality parameters in the East Fork of the Stones River, Murfreesboro, Tennessee, USA. In 2024 and 2025, water (surface and subsurface), sediment, aquatic emergent insects, and riparian tetragnathid spiders were collected approximately weekly from three sites and were analyzed for microcystin content by ELISA. Basic water quality parameters were measured during each sampling event, and water samples were also analyzed for reactive phosphorus and nitrate levels. Microcystis cell numbers were quantified by qPCR. Solid Phase Adsorption Toxin Tracking (SPATT) samplers, and Lampsilis fasciola (Wavy-rayed Lampmussel) were placed in concrete silos at each site and collected biweekly during summer 2025. Both were analyzed for microcystin, and mussel foot tissue glycogen was measured for each animal as an indicator of overall health and energy stores. Water microcystin levels were typically below 1 ppb, and sediment levels ranged from 2 to 42 ppb (average 18.3 ppb). Accumulation of microcystin occurred in both aquatic emergent insects and tetragnathid spiders (average 433 and 409 ppb microcystin respectively), inferring trophic transfer since the main source of food for these spiders is aquatic emergent insects. A negative correlation was seen between nitrates and microcystin levels in subsurface water ($r2 = 0.69$) and Microcystis cell numbers were moderately correlated with microcystin concentration ($r2 = 0.62$). Relationships between microcystin levels in mussel vs SPATT samplers and microcystin vs glycogen levels in mussels are currently being analyzed. The data above indicate that microcystin levels vary over time in the Stones River, and that microcystin accumulates in aquatic

organisms and transfers to riparian organisms, providing potential for microcystin impacts in the terrestrial system.

2.02.P-Th268 Designing Test Systems and Enclosures To Improve Environmental Realism During Evaluation of a Reactive Capping Treatment in Contaminated Wetland Sediment

Ellen Chapman[1], Heidi Gavel[1], David Lewis[1], Lauren MacDonald[1], Enobong Udoh[1], Bradley Knockwood[1], Liam Hill[1], Samuel Sequeira[1] and Linda Campbell[1] (1)Saint Mary's University

Environmentally realistic toxicity testing is essential for accurately evaluating sediment remediation technologies under field-relevant conditions. Wetlands in legacy gold mining districts often contain sediments highly contaminated with arsenic (As) and mercury (Hg), creating long-term exposure risks for aquatic organisms. To evaluate a zerovalent iron based Thin Reactive Amendment and Protective Capping (TRaP) system designed to reduce metal(loid) mobility, toxicity, and bioavailability while preserving wetland function, we developed a multi-stage testing framework. Each stage was designed to progressively increase environmental realism in evaluating TRaP performance. Testing advanced from small laboratory vessels to larger intact sediment–plant core systems and ultimately to a 15-month field deployment in mesocosm enclosures. Ecotoxicity and bioaccumulation assessments incorporated multiple trophic levels and endpoints, including survival, growth, biomass, behaviour, oxidative stress biomarkers, and tissue contaminant accumulation. A key focus of this work was the development of adaptable testing systems to support realistic, multi-species sediment and water toxicity assessments. This presentation will describe several of these test systems, including: (1) organism cages integrated into larger sediment test vessels to enable reliable organism recovery and endpoint measurement; (2) flow-through tabletop mesocosms constructed using widely available off-the-shelf components and capable of supporting multiple species simultaneously; and (3) robust field mesocosm enclosures designed to maintain suitable habitat while withstanding field conditions during multi-season deployments. Experimental design and test vessel construction for each stage will be presented alongside an overview of performance outcomes. These testing systems successfully supported evaluation of TRaP under increasing environmental realism. Laboratory and field studies showed TRaP materials were not acutely toxic and reduced sediment and water toxicity as well as Hg and As bioavailability. Dissolved methylmercury and As in overlying water were consistently lower in treated test vessels, and field mesocosms confirmed laboratory findings under seasonal conditions. Overall, this work demonstrates how purpose-built laboratory and field test systems can advance sediment and water toxicity testing by enabling realistic, multi-species assessments of remediation technologies.

2.02.P-Th269 Disagreement Between Laboratory and Field Effects of Sediment Petroleum Hydrocarbon Contamination To Stream Benthic Invertebrates Suggests Differing Exposure Regimes

Ryan Stevenson[1], Sean Engelking[1] and Josh Baker[2] (1)Azimuth Consulting Group Inc., (2)Rise Over Run Environmental, BQE Water. Previously Nautilus Environmental

In this sediment quality triad (SQT) study for petroleum hydrocarbon (PHC) contamination in a forested creek located near a decommissioned natural gas refinery, we have observed meaningful differences between laboratory-measured sediment toxicity and field-observed effects to the benthic invertebrate community. The study follows a typical SQT approach, integrating exposure, laboratory effects and in situ biological

assessments to understand the magnitude and cause of contaminant-driven risks. The main contaminant of concern is weathered free-phase PHCs (C10 to C26 range) with the depth profile of contamination suggesting recovery of a more natural surface sediment layer on top of the historically-spilled PHCs. Toxicity bioassays on surface sediments indicated high mortality (up 100%) to Hyallela azteca and Chironomus dilutus in 10- to 14-day exposures. A follow up toxicity identification evaluation implicated PHCs and associated aromatic compounds as the toxicant. Concentration-response relationships with PHC exposure were strong, but estimated benchmarks were higher than those developed elsewhere suggesting decreased toxicity due to weathering or an alternative mode of action. Despite the high hazard implied by the laboratory results, observed effects to the in situ benthic invertebrate community were mild with indications that structure and function is being maintained. Our hypothesis to explain these disparate results is that the exposure regimes differ between the laboratory bioassays and instream conditions. Where in-PHCs occur in sediments as patchy globules with higher concentrations at depths below the biologically active zone, a functional benthic invertebrate community appears to be maintained. However, when these PHC-impacted sediments are tested in the lab, pre-mixing distributes the patchy PHCs evenly throughout the sample, resulting in high laboratory toxicity. This conceptual understanding is important for risk management decisions, particularly in situations where sediment remediation to a laboratory-derived benchmark might cause significant disturbance to a functional benthic invertebrate community.

2.02.P-Th270 Evaluating Alternative Formulated Sediments for Sediment Toxicity Tests Using Chironomus riparius

Amos Kaldor[1] and Elizabeth Ostermann[1] (1)Eurofins EAG Agroscience, LLC

OECD guidelines for the testing of chemicals recommend the use of formulated sediment that includes sphagnum peat moss (PM) as the primary source of organic carbon and moisture buffer for sediment-dwelling organisms. The RePeat (Replacement of Peat in Artificial Soil and Sediment) initiative calls for alternatives to peat moss in preparation of artificial sediments and soils due to concerns for environmental sustainability, worldwide availability, and physiochemical standardization. Coconut coir (CC) and alpha-cellulose (AC) are proposed alternatives to PM in OECD formulated sediment, however there is limited data investigating these alternatives with sediment-dwelling organisms according to OECD test guidelines. To assess the feasibility of using alternative formulated sediments without the inclusion of PM, Eurofins conducted tests with C. riparius according to OECD test guideline 218. The tests compared organism performance (emergence ratio, ash-free dry weight and time to emergence) in sediments formulated with PM, CC and AC. Sediments were prepared according to the specifications in OECD 218 with the exception of the replacement of PM with CC or AC as appropriate. Statistical analyses of the data were used to compare the performance of C. riparius in the CC and AC formulated sediments to C. riparius in the PM formulated sediment. Results of these analyses were used to determine if alternative formulated sediments are a viable option for OECD toxicity testing.

2.02.P-Th271 Toxicity Evaluations for Real Environmental Sediments Collected From Osaka Bay, Japan - Differences in Risk Estimated From Evaluations Using Marine Amphipods and Fish Embryos

Seiichi Uno[1], Sana Imazeki[1], Kazuki Imamura[1], Masatoshi Yamasaki[1] and Emiko Kokushi[1] (1)Kagoshima University

Chemicals released through human activities are transported to coastal areas by rivers, rainfall, and other pathways, and ultimately settle in sediments. Some pollutants are poorly degradable and can remain buried for long periods due to ongoing sedimentation, potentially affecting benthic organisms individually or in combination. In worst case, specific organisms might be almost extinct in seriously polluted circumstances. To understand these risks, it is essential to conduct evaluations for effect in organisms exposed to sediments and accurately understand environmental conditions; however, those methods have not been established completely. Owing to evaluating the risks derived from pollutants in sediments, we have developed a method using fish embryos. Because embryos are placed directly on polluted sediments with only a small amount of pore water and no overlying water, this approach can understand directly sediment toxicities. However, many organisms use sediments as their habitats, their sensitivities to pollutants and absorbed pathways of pollutants into the organisms might be different among them. Therefore, the establishment using a few benthic organisms is essential to evaluate more accurately. We focused on marine amphipod, Ptilohyale barbicornis, inhabiting in coastal sediments, which is continuously reared in our laboratory for over 20 years.

In the present study, we compared the toxicities using fish embryos of Java medaka, Oryzias javanicus, which is marine fish, and amphipod, P. barbicornis, exposed to field sediments collected from 8 sites in Osaka Bay, Japan. Because the Bay closes to big cities, Osaka, Kobe, and Sakai cities, has big industrial areas and ports, and has only 2 exits for flowing out, it is easily polluted by several chemicals derived from human activities.

The evaluations using Java medaka embryos showed severe sediment toxicities along costal areas on east side of the Toxicities for amphipods exposed to sediments relatively corresponded, although the sensitivities and tendencies. On the other hand, toxicities in amphipods exposed sediments collected from a site were very serious, although those in Java medaka were not observed. In our presentation, we will show those differences in detail.

2.02.P-Th272 Overview of the US EPA Risk Assessment Approach for Polycationic Polymers Under TSCA: A Regulatory Perspective

Jeffrey Gallagher[1] and Nicholas Turner[1] (1)U.S. Environmental Protection Agency (US EPA)

The United States Environmental Protection Agency (U.S. EPA)’s New Chemicals Division (NCD) evaluates risks to human health and the environment from new chemicals prior to their introduction into U.S. commerce under Section 5 of the Toxic Substances Control Act (TSCA). Of the greater than 800 new chemicals that were submitted to the U.S. EPA during fiscal year 2023 and 2024, approximately 8% fit into the TSCA New Chemical Category of Polycationic Polymers (any polymer that exists in the environment with multiple positive charges; https://www.epa.gov/system/files/documents/2024-02/ncp_chemical_categories.pdf). Polycationic polymers are commonly toxic to fish, aquatic invertebrates, and algae under acute and chronic durations of exposure. Previous work has demonstrated that as a polymer’s cationic charge density (i.e., percent amine-nitrogen) increases, toxicity to aquatic life often increases exponentially (this toxicity may be mediated by sorption to humic acid). This presentation provides an overview of the U.S. EPA’s approach for assessing

cationic polymers. In addition, this presentation will highlight the risk assessment process for estimating environmental concentrations of concern (COCs) and risks in a data-poor environment. There will be a discussion about the role of humic acid in the environmental hazard assessment of polycationic polymers along with U.S. EPA and Organization for Economic Cooperation and Development (OECD) guidance (EPA Test Guideline 850.1085 and OECD Guidance Document 23) to test for potential mediation of toxicity with the addition of humic acid. The latter part of the presentation will discuss current regulatory challenges and opportunities when assessing polycationic polymers for risk assessment purposes.

Disclaimer/Disclosure: Disclaimer: The views expressed in this session are those of the authors and do not necessarily represent the views or policies of the US Environmental Protection Agency.

2.02.P-Th273 Use of the Tissue Residue Approach for Ecological Risk Assessment of per- and Polyfluoroalkyl Substances in Aquatic Systems

Tyler Linton[1], Keith Taulbee[1], Craig Voros[1], Maggie Petersen[1] and John Barkach[2] (1)Great Lakes Environmental Center Inc. (GLEC), (2)Great Lakes Environmental Center, Inc. (GLEC)

Per- and polyfluorinated substances (PFAS) are a broad group of persistent industrial chemicals now proved ubiquitous in the environment. While the field of PFAS environmental research continues to develop rapidly, substantial knowledge gaps remain. Specifically, critical gaps exist regarding the mechanism(s) of PFAS toxicity and bioaccumulation in tissues of exposed aquatic organisms. The objective of this presentation is to discuss and critically evaluate the application of the tissue residue approach (TRA) to facilitate ecological risk assessment (ERA) of PFAS in aquatic systems. The TRA employs the use of tissue concentrations as the dose metric for characterizing toxicant potency. Tissue concentrations hold several advantages to calculate toxicity metrics (i.e., a likely reduction in toxic response variability among all species for a given compound, an improved ability to address mixture toxicity, an increased use of information on modes and mechanisms of toxic action, and a likely reduction in the number of species needed to characterize toxicant potency). The utility of the TRA for ERA for PFAS is expected to depend on numerous factors, such as the specific PFAS compounds and PFAS mixtures aquatic organisms are exposed, exposure characteristics, and availability of tissue residue-response data. The focus of this presentation is on the evaluation of the relative strengths of applying approach in the context of assessing PFAS risk to the environment, the current available data and understanding of the limitations of this approach, and uncertainties with respect to residue-based methods for characterizing toxicity and bioaccumulation in aquatic organisms. The TRA may prove particularly effective for evaluating and reducing uncertainty related to real world field exposure and risk of PFAS chemicals and their mixtures. Approaches for extrapolating residue-based toxicity data across species, tissues, and exposure durations will be explored and discussed. This includes the use of bioaccumulation factors for translating tissue residue criteria into corresponding water and sediment criteria to predict most vulnerable species in an assemblage (i.e., highly exposed and highly sensitive species). Application of the TRA in an actual ecological assessment will be presented, along with estimation and summarization of critical body residues (CBR) from readily available data in the public domain.

2.02.P-Th274 Acute Toxicity of the Neonicotinoid Clothianidin to Aquatic Macroinvertebrate Species, Chironomus dilutus and Neocloeon triangulifer

Corinne Sweeney[1], Lisa Webb[2], Jeff Steevens[3], Rebecca Dorman[3], Adam Moody[3] and Arianne Messerman[4] (1)Missouri Cooperative Fish and Wildlife Research Unit, University of Missouri, (2)U.S. Geological Survey, Missouri Cooperative Fish and Wildlife Research Unit, University of Missouri, (3)U.S. Geological Survey, Columbia Environmental Research Center, (4)U.S. Fish and Wildlife Service

Neonicotinoids are the most widely used group of agricultural pesticides globally, with clothianidin serving as the active insecticidal ingredient in many seed coatings of row crops (e.g, corn and soybeans). Clothianidin's physiochemical properties—high groundwater ubiquity and moderate water solubility—promote contamination of freshwater habitats near agricultural fields. Aquatic insects, which provide critical ecosystem services in freshwater habitats, can become unintended targets of agricultural pesticide applications. To assess the sensitivity of aquatic insects to aqueous clothianidin exposure, we conducted an acute toxicity test using the laboratory-reared non-biting midge, Chironomus dilutus, and the parthenogenic mayfly Neocloeon triangulifer. While C. dilutus has been used regularly in toxicology testing, N. triangulifer has shown particular sensitivity to other contaminants of concern (e.g., PFOA, metals) in recent studies. Test organisms were exposed to a range of ecologically relevant concentrations of clothianidin and held in static conditions for 48 or 96 hours (C. dilutus and N. triangulifer, respectively). Our results indicate that even at low concentrations, clothianidin induced high mortality in exposed mayflies, while midges were more tolerant. This suggests that at current pesticide application rates, some aquatic insects near croplands may face threats to diversity and abundance from clothianidin exposure

Disclaimer/Disclosure: N/A

2.02.P-Th275 Developmental and Endocrine-Related Effects of PFHpA in Zebrafish: Implications for Aquatic Risk Assessment

Taeeun Eom[1] and Kyunghee Ji[2] (1)Yong In university, (2)Yong In University

Perfluoroheptanoic acid (PFHpA) is a seven-carbon perfluoroalkyl carboxylic acid (PFCA) that is increasingly detected in aquatic environments through direct release and transformation of PFAS-related precursors. Compared with legacy long-chain PFAS, toxicological information for PFHpA remains limited, creating uncertainty in aquatic hazard and ecological risk assessment. This study evaluated developmental and endocrine-related effects of PFHpA in zebrafish embryos and larvae and examined their implications for aquatic risk assessment.

Wild-type zebrafish embryos were exposed to PFHpA (0–10 mg/L) for 96 h following OECD Test Guideline 236. Developmental endpoints, including coagulation, hatching, survival, malformation, body length, wet weight, and heart rate, were assessed. Endocrine-associated responses were evaluated by quantitative real-time PCR analysis of genes related to the growth hormone/insulin-like growth factor (GH/IGF) axis and thyroid hormone signaling pathways. In addition, available ecotoxicity data were compiled to derive a predicted no-effect concentration (PNEC) and conduct a screening-level ecological risk assessment.

PFHpA exposure did not induce significant mortality or severe malformations, indicating limited overt acute toxicity. However, significant alterations in body length, wet weight, heart rate, and endocrine-related gene expression were observed across multiple exposure concentrations. Changes in GH/IGF- and thyroid axis-

related genes suggested disruption of pathways involved in growth regulation, metabolism, and early development. These findings indicate that conventional acute toxicity endpoints may underestimate the biological effects of PFHpA. Based on the most sensitive available toxicity endpoint, a PNEC of 36.4 ng/L was derived. Comparison with reported environmental concentrations yielded hazard quotient (HQ) values of up to 5.19, suggesting potential ecological concern under certain exposure scenarios.
Overall, PFHpA induced measurable developmental and endocrine-associated responses despite limited acute toxicity. The integration of sensitive developmental and molecular endpoints with ecological risk assessment provides a more comprehensive basis for hazard characterization and supports the incorporation of mechanistically relevant endpoints into the assessment of emerging PFAS in aquatic environments.

Disclaimer/Disclosure: Acknowledgement: This study was supported by the Chemical Safety Management Specialized Graduate School Program funded by the Ministry of Climate, Energy and Environment of the Republic of Korea and administered by the Korea Environment Conservation Agency (KECA) in 2026.

2.02.P-Th276 Uranium Toxicity to Freshwater Biota and the Influence of pH, Hardness and Dissolved Organic Carbon

Melanie Trenfield[1], Andrew Harford[1], Adam Peters[2], Graham Merrington[2], Lucy Kennelly[2], STEPHEN LOFTS[3], Matti Leppanen[4], Karsten Liber[5], Markus Hecker[5], Johanna Jarvisto[6], Torbjörn Karlsson[7], Andreas Aronsson[8] and Nils Eriksson[9] (1)Department of Climate Change, Energy, the Environment and Water (DCCEEW), (2)wca environment Ltd., (3)United Kingdom Centre for Ecology & Hydrology (UKCEH), (4)Finnish Environment Institute (SYKE), (5)University of Saskatchewan, (6)Finnish Environment Institute, (7)Luossavaara-Kiirunavaara AB (LKAB), (8)Andreas Aronsson Consulting AB, (9)Boliden

The bioavailability and aquatic toxicity of uranium (U) are influenced by physicochemical water quality parameters, including pH, hardness, and dissolved organic carbon (DOC). A chronic bioavailability model for uranium in freshwater systems is currently being developed to improve environmental risk assessments across a range of water quality conditions.
Chronic toxicity data for U were generated for two tropical freshwater species, Hydra viridissima (96-h population growth rate) and Chlorella sp. (72-h cell division), across a pH range of 5.5–8.5 in extremely soft water. Both species were exposed to U under four hardness conditions at pH 7: extremely soft (~3 mg/L CaCO3), soft (15 mg/L CaCO3), moderately hard (62 mg/L CaCO3), and hard (120 mg/L CaCO3). Exposures were conducted using uranyl sulfate (UO2SO4·7H2O) in a synthetic diluent with low dissolved organic carbon and alkalinity. HEPES buffer (1–5 mM) was used to minimise pH drift. The effect of DOC (3 mg/L) in natural creek water from northern Australia on U toxicity was also investigated.
Both species were approximately twice as sensitive to U in extremely soft water compared with moderately hard and hard water, while little to no difference in sensitivity was observed between moderately hard and hard conditions. For Chlorella sp., the EC10 increased from 14 µg/L U in extremely soft water and 17 µg/L U in soft water to 30 µg/L U and 35 µg/L U in moderately hard and hard water, respectively. Similarly, the EC10 for H. viridissima increased from 17 µg/L U in extremely soft water to 37–38 µg/L U in moderately hard and hard water.
Based on EC50 values, U toxicity generally increased with increasing pH. For Chlorella sp., toxicity increased 9-fold between pH 5.5 and 8.5, with EC50 values progressively decreasing with each 0.5-unit increase in pH. For H. viridissima, U toxicity was lower at pH 5.5 and greater at pH 8.5, while sensitivity remained relatively

consistent between pH 6 and 8.
Exposure of Chlorella sp. to U in the presence of 3 mg/L DOC at pH 8 resulted in a 3-fold reduction in toxicity compared with exposures conducted in DOC-free diluent. For H. viridissima there was a 2-fold reduction in toxicity at pH 6.5 and 8 in the presence of 3 mg/L DOC. These data will be combined with international datasets to support parameterisation of the bioavailability model, which will subsequently be validated using European water chemistries.

2.02.P-Th277 Uranium Toxicity to Zebrafish in Reconstituted Freshwater at Different pH and Ionic Composition

Karsten Liber[1], Som Niyogi[1], Markus Hecker[1], Adam Peters[2], Graham Merrington[2], Lucy Kennelly[2], STEPHEN LOFTS[3], Matti Leppanen[4], Johanna Järvistö[5], Laura Sysoeva[5], Melanie Trenfield[6], Andrew Harford[6], Nils Eriksson[7], Torbjörn Karlsson[8] and Andreas Aronsson[9] (1)University of Saskatchewan, (2)wca environment Ltd., (3)United Kingdom Centre for Ecology & Hydrology (UKCEH), (4)Finnish Environment Institute (SYKE), (5)Finnish Environment Institute, (6)Department of Climate Change, Energy, the Environment and Water (DCCEEW), (7)Boliden, (8)Luossavaara-Kiirunavaara AB (LKAB), (9)Andreas Aronsson Consulting AB

Water quality characteristics influence the aqueous bioavailability and hence toxicity of many metals and radionuclides, including uranium. Past research has shown that pH is among the most relevant variables in those relationships. Additional variables such as water hardness, alkalinity and dissolved organic carbon can also play important roles. However, surprisingly little is known about the toxicodynamic relationships between these water quality parameters and uranium in key aquatic receptors, hampering environmental risk assessment efforts and guidelines development. This research project is part of a larger effort to generate the data needed to develop a generalized bioavailability model for uranium toxicity to aquatic organisms. The research presented here will focus on the chronic toxicity of uranium to zebrafish (Danio rerio), a model test species, at different aqueous pH levels. Specifically, zebrafish are sub-chronically exposed to incremental concentrations of uranium for 28 d starting with ≤24 hr old embryos. Primary biological endpoints include hatching success, survival at swim-up (approx. day 6), and survival, growth and teratogenicity at 28 d. Test are conducted at six pH levels (6.0, 6.5, 7.0, 7.5, 8.0, 8.5) covering a range of values representative of natural waterbodies. All tests are conducted in reconstituted freshwater with average hardness and alkalinity of approx. 50 mg/L as CaCO3 each and no DOC. Four additional tests will be conducted with different concentrations of Ca, Mg and DOC. Tests conducted at very low alkalinity proved unsuccessful due to a reduced ability at maintaining dissolved uranium (added as uranyl nitrate) at nominal levels. Tests conducted to date show that uranium toxicity to early life stage zebrafish falls in the 0.5 to 5.0 mg U/L range (hatching success and lethality). Preliminary data also suggests that there is an influence of pH on U toxicity. Additional results on survival, growth and developmental deformities across the full suite of water quality variables investigated will be presented (experimentation still in progress).

2.02.P-Th278 Comparative Toxicity of Glyphosate and Commercial Glyphosate-Based Herbicide Formulations in Early Life Stage Zebrafish (Danio rerio)

Samantha Beckert[1], Christina Pasparakis[2] and Sean Godwin[1] (1)University of California, Davis, (2)University of California Davis (UC Davis)

Commercial herbicide formulations virtually never consist of an active ingredient alone. Co-formulants—added

to enhance bioavailability, uptake, and efficacy—are common constituents whose independent ecotoxicological contributions are incompletely understood. Prior work has demonstrated that co-formulant composition can substantially alter formulation-level toxicity, raising questions about whether products standardized by active ingredient concentration are genuinely comparable in their hazard to non-target organisms. For the most widely applied herbicide classes, pairwise comparisons of active ingredient against single commercial formulations exist, yet systematic evaluation across multiple current products under standardized conditions remains limited — leaving the relative hazard of commercially available formulations largely uncharacterized.

We used glyphosate-based herbicides (GBHs) — the most widely applied herbicide class globally — and early life stage zebrafish (Danio rerio) as a model system to examine this question. Pure technical-grade glyphosate was compared against three commercial GBH formulations standardized by active ingredient concentration. Embryos were exposed from 2 to 96 hours post-fertilization to glyphosate, Roundup ProMAX, Cornerstone Plus, or Compare N Save, and assessed for mortality, time to hatch, heart rate, and morphological anomalies. Dose-response curves were used to access toxicity ranges, and ongoing mass spectrometry analyses are characterizing co-formulant composition across products.

Lethal concentration values differed across products, with Roundup ProMAX the most acutely toxic formulation tested. The lethal toxicity of pure glyphosate was closely comparable to its pH-matched controls, consistent with co-formulants as a contributor to the differential toxicity observed among formulations. Sublethal analyses further indicate product-dependent differences in the prevalence of edema, spinal curvature, and time to hatch. These results demonstrate that commercial formulations of the same herbicide class are not toxicologically interchangeable, and that co-formulant composition warrants greater consideration in the aquatic risk assessment of herbicide products.

2.02.P-Th279 Aquatic Biota in Southeast Alaska Transboundary Rivers Are Particularly Vulnerable to Dissolved Metals

Patrick Moran[1] and Connor Johnson[1] (1)U.S. Geological Survey (USGS)

The US Geological Survey has been collecting baseline water quality data, including metals and associated parameters, in five rivers in Southeast Alaska since 2019. Each of these rivers have headwaters in Canada, flow across the US-Canada border to empty into the Pacific Ocean, and play a vital role in the social, economic, and subsistence livelihood of residents in the region. The rivers include the Alsek, Taku, Stikine, Unuk,and Salmon at Hyder rivers. Monitoring to date includes: super gages that continuously record water quality parameters (dissolved oxygen, pH, temperature, turbidity, conductivity, and dissolved organic matter by fluorescence) and are publicly available through the USGS Water Data for the Nation portal. In addition, over 200 water samples and 24 sets of annual solid samples (sediment, moss, algae, fish tissue) for metals analysis across these rivers have been collected. Of these five international watersheds, the highest water and sediment metal concentrations measured were found in the smallest and southernmost watersheds of the Unuk and Salmon at Hyder rivers. For sediment samples, concentrations in these two rivers exceeded the “Consensus- Likely effect concentration” but not “Consensus- Probably effect concentrations”, as reported by MacDonald et al. (2000). For water samples, US EPA Water Quality Criteria for several metals were not exceeded in the northern three rivers (Alsek, Taku and the Stikine), but occasional exceedances were observed when compared to the calculated Biotic Ligand Model (BLM) chronic toxic units for copper in the Unuk and Salmon at Hyder rivers. Comparisons between

BLM calculated, multiple linear regression, and hardness-based water metals criteria and trends between water and sediment at each site are discussed. Review of more than five years of both continuous and discrete monitoring data indicates that very low dissolved organic carbon levels, low major ions, and neutral to slightly acidic pH conditions, confirmed by BLM calculations, suggest that these rivers are more vulnerable than most US rivers to potential effects from elevated dissolved metals.

2.02.P-Th280 Sanitary Quality of Water and Sand at Recreational Beaches in Acapulco, Guerrero, México

Diego Villanueva-Vargas[1], Patricia Ramírez-Romero[1] and Carlos Fernández-Rendón[1] (1)Universidad Autónoma Metropolitana-Iztapalapa

Coliforms and enterococci are bacteria that indicate fecal contamination and are used to evaluate the health quality of water on recreational beaches. This focus on sanitary quality considers the risk tourists face from contaminated seawater. Still, it neglects the potential health hazards of contact with sand, even though tourists come into direct contact with both. The objective of this study was to quantify the concentration of total coliforms, fecal coliforms, and fecal enterococci in water and to determine the presence of fecal enterococci in sand from three recreational beaches in Acapulco Bay. Sampling was conducted during the rainy season, with a high tourist influx, and during the dry season, with a low tourist influx. Sand, seawater, and freshwater samples were taken. Quantification of enteric bacteria was estimated using the Most Probable Number (MPN) method. The results in freshwater samples indicate fecal contamination from wastewater discharges. Seawater analyses revealed that all three beaches exceeded the recommended limit of 200 MPN/100 mL for fecal enterococci, indicating that these sites were unsuitable for primary-contact recreational activities and potentially posed a public health risk. High levels of fecal enterococci in sand were also recorded, ranging from 150 to >11000 NMP/100 g. The highest concentrations were recorded during the rainy season and periods of increased tourist activity. These findings suggest that exposure to beach sand may be an additional, often underestimated pathway of microbial contamination, highlighting the need to incorporate sand quality into recreational beach monitoring programs.

Assessing Toxicity in Water and Aquatic Sediments

2.02.V-01 Interactive Effects of Dredging and Climate Variability on Fish Biodiversity and Habitat Quality of the Benin River, Nigeria

Patricia Uchenna Okeke[1] and Emmanuel Temiotan Ogbomida[2] (1)University of Benin, Benin-City, Nigeria., (2)National Center for Energy and Environment, University of Benin, Benin-City

Dredging activities significantly alter aquatic ecosystems by modifying habitat structure, degrading water quality, and disrupting ecological processes through sediment resuspension, reducing light penetration, and increasing physiological stress on aquatic organisms. These effects may be intensified by climate-driven hydrological variability and intensifying ecosystem degradation. Fish communities are particularly sensitive, as dredging can cause mortality, alter species composition, and promote invasive species establishment. This study assessed environmental quality and fish biodiversity in the Benin River under active dredging and port development which is one its kind in this waterbody. Water and sediment samples were collected across four

stations representing three longitudinal zones, and physicochemical parameters of both water and sediment samples were analyzed using standard procedures. Statistical tools, including ANOVA and Duncan Multiple Range tests, evaluated spatial and seasonal differences, while the Water Quality Index (WQI) examined parameter relationships. Results showed no significant variation ($P>0.05$) in dissolved oxygen (DO), biochemical oxygen demand (BOD_5), sediment organic carbon, and organic matter. However, salinity, electrical conductivity (EC), total dissolved solids (TDS), total hardness, and chemical oxygen demand (COD) were identified as key drivers of water quality of the study area. Sediment contamination indices indicated minimal nickel contamination (CF = 0.12) but very high contamination levels for iron (Fe), cadmium (Cd), and vanadium (V) (CF > 6). A total of 620 fish individuals representing 46 species, 28 families, and 37 genera were recorded, including freshwater and brackish species. Chrysichthys nigrodigitatus was dominant (20.16%). Diversity indices varied spatially, with the highest Shannon index at station 3 (2.394) and lowest at station 4 (1.994). Hutcheson's t-test revealed significantly lower diversity at station 4 ($P<0.05$). Strong positive correlations were observed between fish families and environmental parameters. The study provides baseline data for managing the Benin River ecosystem under increasing anthropogenic pressure.

Disclaimer/Disclosure: This write-up is for educational purpose from a research work conducted in Benin River under the guidance of Animal and Environmental Biology Department, University of Benin, Nigeria. While efforts were made to ensure accuracy, the author makes no guarantees regarding completeness or reliability.

Conducting Toxicity Tests with Non-Standard Test Organisms or Conducting Non-Standard Toxicity Tests

2.03.T-01 Conducting Multiple Single Species Acute Toxicity Studies To Reduce Uncertainty

Alan Samel[1], Suzanne Schneider[2], Henry Krueger[3] and David Funk[4] (1)Stone Environmental Inc., (2)Eurofins Agroscience Services US, (3)Eurofins Agroscience Services Germany Holding GmbH, (4)Stroud Water Research

Acute aquatic invertebrate toxicity tests play a major role in the global pesticide registration process and for endangered species assessments in the United States. Initially, the risk assessment approach starts with acute toxicity tests with a set of 'core' or standard test organisms. For example, the freshwater aquatic invertebrates Daphnia magna and Chironomus riparius are the 'core' aquatic invertebrates that represent the 'universe' of freshwater aquatic invertebrate species. Because the core test organisms represent a small percentage of similar taxa to which exposure could occur, the resulting risk assessment has a high degree of uncertainty. As a result of this level of uncertainty, large safety factors are assigned to the final risk value used to determine the level of risk to the test substance.

To mitigate this high degree of uncertainty, additional laboratory acute toxicity tests of single species can be conducted. These additional test organisms represent not only a broad range of aquatic invertebrate species, but they also represent a broad range of functional groups in the ecosystem. As the number of species tested increases the level of uncertainty decreases. In the EU, at least 8 aquatic invertebrates are required to construct a Species Sensitivity Distribution (SSD) that is used to lower uncertainty levels in the risk assessment, setting the

bar for higher tier aquatic invertebrate toxicity tests. There are similar requirements globally for the minimum number of species needed to construct an SSD to lower uncertainty. But there are many challenges with conducting acute toxicity tests on species that are not 'core' test organisms. For example, while there are standard acute toxicity tests for daphnids and midges there are no standardized test designs for mayflies, stoneflies or caddisflies. As a result, the study designs for these test organisms often reflect the standard test designs as closely as possible and practical. In addition, understanding the life history patterns, life cycles, feeding traits, and diverse habitats is critical and present unique challenges. The objectives of this talk are to discuss the challenges for designing and testing these non-standardized test organisms.

2.03.T-02 Chronic Toxicity Testing With Non-Guideline Aquatic Invertebrates

Suzanne Schneider[1], Elizabeth Ostermann[1], Sean Gallagher[1], Alan Samel[2] and Henry Krueger[1] (1)Eurofins Agroscience Services US, (2)Stone Environmental Inc.

Invertebrate toxicity testing is an important component in the registration process for today's modern chemicals. Although current tier 1 testing requirements primarily focus on standard laboratory-cultured aquatic invertebrates, there is an increasing interest in expanding the range of species evaluated to enhance environmental risk assessments. In recent years, the demand for testing a broader range of invertebrate species for higher tier risk assessment studies has steadily increased to support the development of species sensitivity distributions (SSD) for European risk assessments and for Endangered Species evaluations in the United States.

Current OECD and OCSPP guidelines for invertebrate testing include daphnids, mysids, amphipods, oligochaetes and chironomids. To develop species sensitivity distributions, non-guideline aquatic insects such as stoneflies, caddisflies and mayflies have been incorporated to provide additional toxicity data. For chronic testing, SSD approaches have been implemented in sediment/water systems in accordance with OECD Guidelines 218 and 219. Sediment-water toxicity testing with non-standard and non-guideline freshwater aquatic invertebrates introduces unique challenges for Good Laboratory Practice (GLP) studies.
In this work, we summarize our experience conducting GLP-compliant chronic toxicity tests with additional aquatic invertebrate species and discuss critical factors influencing study conduct and interpretation, including test design, organism availability and age, acclimation procedures, dietary requirements, and the establishment of study-specific validity and acceptability criteria. Key takeaways and practical considerations are presented to inform future testing strategies, including approaches for evaluating control performance, endpoint reliability, and overall study validity in support of method development for expanding species coverage beyond standard guidelines.

2.03.T-03 Evaluating the Toxicological Impacts of Nano- Low-Micrometer Microplastics Exposure on Early Life Stages of Two Freshwater Fish Species

John Conto[1] and Gavin Dehnert[1] (1)University of Wisconsin Madison

Microplastic (MP) pollution is a ubiquitous environmental challenge, yet research often overlooks nano- low-micrometer microplastics (NLMMPs, < 100 □m) in freshwater ecosystems (e.g., Laurentian Great Lakes). While existing research concerning the effects of microplastic exposure to fish has largely focused on adult life stages and relatively larger particles, smaller particle sizes may pose physiological risks to critical developmental life stages (e.g., embryonic) which remain under-investigated, especially in freshwater fish

species. To better understand the impact of NLMMPs on the native fish species residing in Midwest U.S. ecosystems, it is essential to evaluate more species' tolerances to nanoplastic particle exposure and determine what sizes could pass through their protective chorionic membrane. This study investigated the size- and concentration- dependent impacts of exposure to fluorescent polystyrene (PS) nanoplastics in embryonic Walleye (Sander vitreus) and Lake Sturgeon (Acipenser fulvescens), two native Wisconsin freshwater fish species. Embryos from each species (n = 720) were exposed directly after fertilization to one day before hatch (~9 days) to two sizes of fluorescent polystyrene particles (25 nm, 1000 nm) at nominal concentrations of 0, 1.0, 10.0, and 100.0 mg PS L-1 H2O. We utilized a static renewal exposure design to evaluate multiple toxicological endpoints, including survival (%), hatch success (%), deformities (%), respiration rates (MO2), and corrected total cell fluorescence (CTCF). We did not observe any significant differences in survival due to acute exposure to either size or any concentration tested for walleye ($p > 0.05$), however tissue fluorescence was significantly higher in the 25 nm size group as compared to the 1000 nm group, as well as at the highest concentration tested compared to controls for walleye ($p = 3.69 \times 10\text{-}4$; $p = 2.2 \times 10\text{-}16$). Additionally, we found significant increases in respiration as concentrations increased for both sizes of walleye ($p = 0.0442$, 25 nm; $p = 0.0463$, 1000 nm). Sturgeon experiments are ongoing. Preliminary assessment suggests that the physical size limit of particles that can enter the embryo is < 1000 nm. Our research provides a critical baseline for evaluating nanoplastics exposure to a vulnerable stage of ecologically and economically significant freshwater fish species.

Disclaimer/Disclosure: Funding from NOAA Grant #122 AAN9352 349610-4

Travel Award funding from Midwest Regional SETAC 2026 Best Student Oral Presentation Award provided by SC Johnson, Racine WI

2.03.T-04 Comparative Sensitivity Analysis of the RTgill-W1 Assay, FET Test, and Traditional Whole-Effluent Toxicity Test Methods

Erin Ussery[1], Jack Salole[2], Lisa Taylor[3] and Joanna Wilson[2] (1)Environment and Climate Change Canada (ECCC), (2)McMaster University, (3)Nautilus Environmental Company

Effluent testing is an often-overlooked contributor to animal use, accounting for an estimated 5 million fish annually in regulation worldwide. Standard whole-effluent toxicity testing currently relies on acute lethality tests using rainbow trout (Oncorhynchus mykiss) and Daphnia magna; however, growing pressure to reduce animal use has spurred considerable interest in alternative approaches. While substantial research has developed new approach methods (NAMs) for chemical risk assessment, few studies have directly compared the sensitivity of these approaches to traditional methods for assessing whole-effluent toxicity. As a first step toward addressing this gap, we present preliminary findings from a case study evaluating a municipal effluent sample using a combination of NAMs alongside established reference methods. We focus on two emerging NAMs with regulatory potential: the RTgill-W1 cell line assay (ISO 21115), which uses cells derived from rainbow trout gill tissue; and the fish embryo toxicity test (OECD 236), conducted in walleye (Sander vitreus), zebrafish (Danio rerio), and fathead minnow (Pimephales promelas). This research provides insight into the sensitivity of new models at various levels of biological organization to effluents that will be critical in identifying suitable replacements to the most commonly applied whole-effluent toxicity test method worldwide.

2.03.T-05 Exploring the Efficacy of Herbicide Mixtures on Dolichospermum and Microcystis

Andrew Barrick[1], Sayem Ahmed[2], Ben Beck[3] and Tham Hoang[2] (1)Auburn Univeristy, (2)Auburn University, (3)USDA-ARS

Harmful cyanobacterial blooms (HCBs) are an emerging issue commonly linked to human activity. As the Anthropocene progresses, there is growing interest in optimizing treatment strategies to reduce HCBs without adversely affecting ecosystems. Currently, copper-based herbicides are the most common method for reducing harmful algal blooms in both natural ecosystems and aquaculture ponds. However, copper is indiscriminate and transient, and it may accumulate in sediments over time. In practice, commercial herbicides contain multiple ingredients, often combined into a single product. Some aquaculture practices also mix herbicides to improve treatment. Surprisingly, limited information is available on how herbicide mixtures may affect cyanobacteria. The aim of the present study was to investigate the effectiveness of herbicide mixtures in reducing cyanobacterial growth. The study focused on two genera, Dolichospermum and Microcystis, as they are the most common freshwater HCB genera.

Preliminary data were generated for 15 herbicides to assess their efficacy in reducing cyanobacterial growth. A short list of 6 herbicides (bispyribac sodium, copper, diquat, diuron, hydrogen peroxide, and penoxsulam) was identified as effective against cyanobacteria. Several mixture studies were conducted to determine whether copper mixed with organic herbicides, a practice used in agriculture, was more effective than copper alone. Sequential binary exposures were also conducted to determine whether preliminary exposure to hydrogen peroxide made cyanobacteria more susceptible to copper. High-throughput screening was used to preselect binary organic herbicide mixtures that were more effective than a single herbicide. Binary mixtures were explored to determine whether these relationships were additive or synergistic.

The study demonstrated that copper mixed with diquat at certain ratios was synergistic, whereas other copper mixtures were either additive or antagonistic. Initial results for binary organic mixtures suggest they are additive rather than synergistic. The research focuses on identifying the most effective approaches for treating harmful algal blooms in aquaculture ponds and on providing recommendations to enhance treatment methods. However, it is important to consider the long-term environmental implications of these herbicides and the costs associated with their use.

Disclaimer/Disclosure: The research was funded through the United States Department of Agriculture's Agricultural Research Service Cooperative Agreement #58-6010-3-006.

2.03.T-06 Chemical Contaminant Inhibition of Settlement and Survivorship in Caribbean Coral Larvae

D. Abigail Renegar[1], Ellen Regina Skelton[1] and Carys Mitchelmore[2] (1)Nova Southeastern University, (2)University of Maryland Center for Environmental Science

Early life stages of corals are generally regarded as more sensitive to contaminants compared to adults. Spawning and larval development of most coral species on Florida's Coral Reef occurs through the summer and fall, which coincides with substantial rain-event driven events associated with risk of exposure to chemical contaminants in the water column and sediment/substrate. The inhibition of larval settlement and metamorphosis, which are crucial developmental steps and ultimately determine survival, have been examined

for a very limited range of chemical contaminants and coral species. Potential impacts remain largely unknown and may have significant implications for coral reef management and restoration efforts.
Montastraea cavernosa and Diploria labyrinthiformis larvae were exposed to contaminants as nominal dissolved concentrations or pre-contaminated settlement tiles, and tiles checked for settlement and metamorphosis daily for 4-7 days. Test contaminants included metals (copper, arsenic, zinc), hydrocarbons (chrysene, fluoranthene, pyrene, phenanthrene), and common organic pollutants (tributyltin, diuron, and octocrylene) as these chemicals are waterborne and/or sediment-associated contaminants recognized for potential toxicity. These contaminants were identified in a recent metanalysis as contaminants of potential impact as they have been detected at concentrations which exceed both EPA water quality standards and State of Florida threshold and/or probable effects levels in waters and sediments across the southeast coast of Florida.
Significant reductions in settlement were observed for dissolved exposures to fluoranthene, phenanthrene, pyrene, diuron, octocrylene, and tributyltin and for settlement tiles contaminated with copper, zinc, pyrene, and octocrylene. Non-significant dose-related reductions in settlement were also observed for other dissolved and contaminated tile exposures. This study has thus far identified preliminary thresholds of effect for common inorganic and organic chemical contaminants exposure for settlement in Atlantic corals, and provided a framework for the establishment of standardized toxicity test methods for coral early life stages which are essential for determining the environmental risk of chemical contaminants on coral reefs. The sensitivity of these coral species to contaminants indicates that this may be a significant barrier to larval recruitment on the reef framework, and a limiting factor in reef recovery.

Conducting Toxicity Tests with Non-Standard Test Organisms or Conducting Non-Standard Toxicity Tests

2.03.P-Th001 Investigating the Effects of Malathion and UVA Radiation in White Sea Urchin Larval Development

Cristina Torres Duarte[1], Francine De Castro[1], Aisyah Suripto[1] and Christina Pasparakis[1] (1)University of California Davis

Organophosphate pesticides are widely used worldwide for commercial, residential, and agricultural insect pest control. Among them, malathion exerts toxicity primarily through inhibition of acetylcholinesterase. Once released into the environment, malathion can undergo oxidation to form malaoxon, a more potent acetylcholinesterase inhibitor. In this study, we investigated the combined effects of malathion and the natural environmental oxidizer ultraviolet A radiation (UVA) during early embryonic development of the non-target marine organism white sea urchin (Lytechinus pictus).
Embryos were exposed from the 4-cell stage through the pluteus stage for a total of 96 h under different pesticide and light treatments. Under dark conditions, malathion exposure resulted in an EC50 of 3.04 mg/L based on morphological endpoints. The most common effects observed were delayed development, abnormal skeletal formation, and mortality. To evaluate the influence of light exposure, embryos were exposed to darkness, photosynthetically active radiation (PAR), or UVA for 6 h per day, totaling 24 h of light exposure over the experiment. Interactive effects between malathion and UVA were observed at concentrations of 5 mg/L and higher, resulting in significantly reduced normal development under light treatments compared to dark controls. These findings initially supported the hypothesis that light-driven oxidation of malathion could

increase toxicity through conversion to malaoxon.
However, direct exposure experiments with malaoxon revealed a higher EC50 (9.92 mg/L), indicating lower toxicity than malathion under the tested conditions. These results suggest that the enhanced toxicity observed under UVA exposure is likely not driven by malathion oxidation to malaoxon, but rather by combined stress mechanisms that may impair overall metabolic function. Additional experiments are currently being conducted to quantify oxygen consumption as a proxy for metabolic rate and further investigate the mechanisms underlying the interaction between malathion and UVA exposure.

2.03.P-Th002 Assessment of Caribbean Gorgonians Response to Acute Copper Exposure

Brady Estrada[1], Dorothy-Ellen Renegar[1] and Carys Mitchelmore[2] (1)Nova Southeastern University, (2)University of Maryland Center for Environmental Science

Caribbean reef building corals have faced notable environmental degradation over the last four decades due to severe heat stress and exposure to aquatic contaminants; however Caribbean gorgonian populations have remained relatively robust regardless of exposure to the same stressors. Despite their dominance in the Caribbean, there has been no research focusing on the toxicity threshold of gorgonians to aquatic contaminants, and there is no standard methodology available to test and evaluate this group of organisms. Copper is a common contaminant in coastal waters and often used as a standard reference chemical for toxicity studies. Common sources of copper pollution include industrial discharge, agricultural runoff, sewage treatment plants, and antifouling paints. The goals of this project are to improve our understanding of gorgonian resilience in the Caribbean by conducting experiments using the gorgonian species Antillogorgia americana and Plexaurella nutans to determine their acute toxicity thresholds for dissolved copper, and establish baseline methodology and stress assessment metrics specific to this group of benthic organisms. Each species were exposed to 6 concentrations of dissolved copper ranging from 0 µg/L to 400 µg/L in 96 hour acute static-renewal toxicity tests. For each species response thresholds for mortality (LC50), symbiont photosynthetic rate (IC50), and behavioral/physical changes (EC50) were calculated. Results are compared to current water quality standards and acute thresholds for other reef organisms to determine if gorgonians are more resilient than reef building corals to copper exposures, which may play a role in their persistence in these reef environments. The information gained can be applied to our understanding of how local environmental stressors impact reef configuration, as well as how current reef dominating species such as gorgonians can be used as bioindicators for compromised water quality.

2.03.P-Th003 Biological Impacts of Alternative Fuel Spills on Blue Mussel (Mytilus edulis) and Sea Scallop (Placopecten magellanicus) Under Winter Conditions

Carolanne Ducasse[1], Richard Saint-Louis[1] and Réjean Tremblay[1] (1)University of Quebec at Rimouski (UQAR)

Although maritime shipping is one of the main drivers of the global economy, it is a significant contributor to atmospheric pollution. Annual emissions from maritime transport account for nearly 15% of global nitrogen oxide (NOx) emissions and 5.8% of sulfur oxide (SOx) emissions. To reduce these emissions, the International Maritime Organization (IMO) implemented stricter regulations in 2020 regarding marine fuel emissions. The reduction of the sulfur content limit in fuels, now dropping from 3.5% to 0.5%, has driven a transition toward alternative fuels. Biodiesels of 100% plant-based or organic origin, such as B100, composed of fatty acid methyl esters (FAMEs), are gaining ground, as is hydrotreated vegetable oil (HVO). Although these fuels

contain little to no sulfur, their biological effects on marine fauna remain poorly understood. Additives are also incorporated into these fuels to ensure stability against the risk of oxidation. One such additive is butylhydroxytoluene (BHT), an antioxidant harmful to aquatic life due to its low biodegradability and risk of bioaccumulation. Few studies have assessed the ecotoxicological risks of biofuels in the event of a spill under winter conditions. This project therefore aims to evaluate the sublethal biological effects of biodiesels, such as B100 and HVO, under winter conditions on the blue mussel (Mytilus edulis) and the sea scallop (Placopecten magellanicus). The selection of these bivalves is linked to their commercial importance in the Gulf of St. Lawrence, as well as their distinct anatomical traits. The short-term biological effects of adult bivalves (7-day exposure) will be studied. The experiment will simulate, in a 3,500-liter outdoor mesocosm, a biodiesel spill covering a surface area of 1 km². Following exposures, the bivalves will undergo a 4-week depuration period in an indoor mesocosm with continuous seawater flow, in order to assess their resilience capacity and subsequent reproductive performance in an uncontaminated environment. Throughout the exposure and depuration periods, sublethal biological effects in adults will be measured through biomarker responses and correlated with the results of chemical analyses of water samples and bivalve tissues.

2.03.P-Th004 Chemical Modulation of the Motility of Mytilus edulis Haemocytes in a Microfluidic Device

Suzie Severino[1], Richard Saint-Louis[2], Réjean Tremblay[2], Sébastien Cardinal[2] and Frank Le Foll[3] (1)University of Quebec at Rimouski (UQAR), (2)UQAR, (3)SEBIO - ULHN

The presence of multiple pollutants and their persistence lead to their accumulation in various environments, as well as in living organisms. Ecotoxicology faces new analytical limitations linked to the complexity of the environmental matrices under study, as well as that of the pollutants to be analysed. Microfluidics is emerging as a solution to this problem thanks to its many advantages, notably high-throughput screening and high-content imaging, carried out on small sample volumes. The introduction of microfluidics into marine ecotoxicology is still in its infancy. Pending the standardisation of protocols, a well-known biological model, the blue mussel, is being used to demonstrate the feasibility of this approach. These filter-feeding organisms are constantly exposed to various pollutants. The presence of harmful substances can impair their immune defences and threaten their survival. The immunity of bivalves relies solely on innate defences involving cellular mechanisms, mediated by circulating haemocytes capable of migrating to infected or damaged sites. The movement of these cells is crucial during the immune response. In this study, we apply the analysis of this key parameter to microfluidic cell culture systems by investigating the impact of polyaromatic compounds, such as carbazole and dibenzothiophene, on the motility of blue mussel haemocytes. Motility is quantified using time-lapse microscopy, which allows us to measure cell velocities. The results are expected to show that these pollutants can inhibit the migration of haemocytes, thereby weakening the immune response and reducing the survival of the organisms.

2.03.P-Th005 Hypercapnia Reveals Conserved Molecular Signatures of Cardiac Stress and Remodeling in Lumpfish Under Simulated Deep-Sea Pressure Conditions

Vimbai Irene Machimbirike[1], Luis Tejerina Pardo[1], Oluwatoyin Bukunmi Onireti[1], Sathees Duglas[1], Rebecca Ruth Kwabiah[1], Jennifer Hall[1] and Javier Santander[1] (1)Memorial University of Newfoundland

Anthropogenic accidental CO_2 emissions can potentially increase hypercapnic conditions in marine

environments. These challenges may be compounded by elevated hydrostatic pressure, yet the combined effects of these stressors on cardiac function remain poorly understood. Here, we investigated the integrated effects of environmental CO_2 (0.5589 mg/L; pH 8.2), low CO_2 (1.5107 mg/L; pH 7.8), high CO_2 (10.2873 mg/L; pH 7.0), and 24 h recovery following high CO_2 exposure on lumpfish (Cyclopterus lumpus) heart at surface pressure (0 m) and simulated deep-sea pressure (800 m). Using a multi-omics framework of transcriptomics and proteomics, together with blood biochemistry and histology, we characterized multi-scale cardiac responses to hypercapnia and hydrostatic pressure. At 0 m, low CO_2 induced early compensatory responses to acid-base disturbance while high CO_2 triggered extensive molecular stress remodeling. Recovery following high CO_2 exposure partially restored tissue integrity and metabolic function; however, persistent dysregulation of stress-responsive pathways suggested incomplete recovery. Hydrostatic pressure at 800 m substantially amplified the cardiac effects of hypercapnia. At 800 m, low CO_2, the heart underwent adaptive restructuring with pathways linked to heart morphogenesis upregulated. Meanwhile at high CO_2, stress and repair genes were upregulated while suppressing energy-generating and biosynthetic processes. Recovery following high CO_2 exposure at 800 m revealed regeneration and repair while heart morphogenesis and function were suppressed. Histological analyses revealed structural changes within both compact and spongy myocardium, consistent with impaired cardiac homeostasis. Multi-omics integration revealed concordant transcriptomic and proteomic signatures indicative of sustained cardiac stress. There was no significance increase in blood biomarkers linked to heart damage. The concordant genes and proteins myh6 and pfk1a were identified as potential biomarkers. These findings demonstrate that hypercapnia in the presence or absence of hydrostatic pressure results in cardiac dysfunction in lumpfish, and potential biomarkers identified can help in diagnosis of affected lumpfish in marine environments.

2.03.P-Th006 Establishing Moina macrocopa as a New Standard Species for OECD Test Guideline 211 (Daphnia Reproduction Test)

Haruna Watanabe[1], Yusuke Oda[1], Woo-Mi Lee[2], Eunbi Moon[2], Jaewoong Lee[2] and Hiroshi Yamamoto[1]
(1)National Institute for Environmental Studies (NIES), (2)National Institute for Environmental Research (NIER)

The Daphnia magna reproduction test, based on OECD Test Guideline 211 (TG 211), has been used worldwide for decades to assess the ecological effect of chemicals, effluents, and receiving waters. However, TG 211 requires 21 days to observe 5–6 broods, and counting approximately 100 offspring per individual (totaling 1,000–6000 offspring per test) is labor-intensive.
In addition, D. magna originates from North America and is not indigenous in the South Hemisphere or most parts of Asia, except China. To protect local ecosystems, there is increasing demand to use indigenous species in ecological hazard and risk assessment of chemicals, as well as in establishment of water quality criteria for aquatic life. This need arises from differences in species diversity, geographical distribution, and sensitivity among cladocerans.
According to TG 211, “other daphnids may be used provided they meet the validity criteria as appropriate”. Therefore, we propose Moina macrocopa as a new test organism for TG 211. M. macrocopa is a cosmopolitan species commonly found in ponds and rice paddies in East Asia. Although it has been used in several ecotoxicological studies, a standard test guideline using M. macrocopa has not been established yet. We have developed a three-brood reproduction test using M. macrocopa, based on the Cerioadaphnia dubia three-brood reproduction test (USEPA, ISO, etc.). Moina macrocopa begins reproduction within 3–4 days after birth and

produces broods every two days, requiring 8–9 days to complete three-broods at 21 °C. This shorter test duration—approximately one-third of that required for 21-day D. magna reproduction test—offers significant advantages in terms of resources savings (time, cost, space, and labor). Moreover, M. macrocopa is more prolific than C. dubia, producing approximately twice as many offspring, which is expected to provide greater statistical power for detection effect.
The draft guideline now requires validation through an interlaboratory ring test, in which multiple laboratories from Korea and Japan will conduct M. macrocopa reproduction test according to the proposed protocol to evaluate its robustness and reproducibility. In this presentation, we will report the preliminary results of the ring test using two reference chemicals (NaCl and 3,4-dichloroaniline).

2.03.P-Th007 Acute and Chronic Effects of Antifouling Paint Micro and Nanoplastics to Planorbidae Snails Using 'Omics'

Philip Johnsen[1], Ana C. Quevedo[1], Georgina Kalogerakis[2], Pedro Mena-Giraldo[1], John-Paul Haber[1], Bonnie Hamilton[3], Stacey Robinson[4], Kevin Wilkinson[5] and Nathalie Tufenkji[1] (1)McGill University, (2)Université Laval, (3)University of Ottawa, (4)Carleton University, (5)University of Montreal (UdeM)

To prevent the growth and attachment of aquatic plants and fauna to boat surfaces (biofouling), boats are often painted with antifouling paint. These paints wear away resulting in the release of antifouling paint particles (AFPPs) into aquatic ecosystems. These AFPPs represent an environmentally relevant source of microplastic and nanoplastic contamination made of a plastic polymer base, biocides, plasticizers, and metals such as copper, zinc, and iron. As AFPPs flake off and degrade in the environment, chemicals may leach into waters accumulating in sediments or water columns leading to various routes of exposure for aquatic organisms. While AFPPs are known to cause acute toxic effects, the potential sublethal/chronic effects and toxicity mode of action are widely unknown. Previous toxicity studies typically do not assess sublethal or chronic effects, frequently employing acute tests in a limited range of taxa. Toxic effects are often attributed to leached metals; however, the particles may contribute to toxicity. Presently, there is a need for chronic and sublethal toxicity data for AFPPs in a broader range of taxa.

In this study, an acute 48-hour assay investigating Planorbidae snail survival, tissue histology, behaviour, and metabolomics is used to assess AFPP toxicity. Planorbella duryi was selected to meet minimum mass requirements and to provide toxicity data in previously untested species. An untargeted metabolomic assessment using proton nuclear magnetic resonance (1H-NMR) will help identify alterations in metabolite levels. This acute experiment will inform toxicity test conditions for a 28-day study investigating chronic effects of AFPPs to P. duryi snails assessing survival, tissue histology, food consumption, behaviour, DNA damage (Comet Assay), and multi-omics. Omics assessments will include an untargeted (using 1H-NMR) then targeted (using Liquid Chromatography–Mass Spectrometry) metabolomic assessment, proteomics, and mRNA gene expression. Furthermore, comparisons will be made between the results of the acute and chronic experiments to strengthen analyses. Data from this project will be used to inform toxicity assessments of AFPPs. In particular, the sublethal and chronic effects of AFPPs will help us to better understand the potential impacts of these contaminants to aquatic ecosystems. Furthermore, omics results will help to draw inferences on the toxicity mode of action of AFPPs and potentially allow for the development of biomarkers.

2.03.P-Th008 You Are What You Eat: Examining Trophic Role in Comparative Microplastic Uptake and Toxicology Among Shark Species

Gregory Aniolek[1], Paige Powell[1], Stefanie Whitmire[1], Peter van den Hurk[1] and Kylie Rock[1] (1)Clemson University

Microplastics (MPs; <5 mm) are an emerging class of environmental pollutants that are now considered a global ecotoxicological concern due to their persistence, ubiquity, and potential for biological interaction. MPs are introduced into marine systems through urban runoff, wastewater effluent, and degradation of larger plastic debris, where they absorb hydrophobic contaminants and concentrate in sediments and biota. Mounting evidence from laboratory models, including zebrafish, bivalves, and marine worms, demonstrates that MPs can induce oxidative stress, inflammation, reproductive impairment, as well as altered behavior through physical obstruction, reactive oxygen species (ROS) generation, and endocrine disruption. However, data on the biological effects of environmentally relevant MP concentrations in large marine vertebrates remain sparse, particularly in long-lived predators such as sharks. Coastal South Carolina estuaries, including Charleston Harbor and Winyah Bay, represent MP hotspots, receiving high inputs from urban, industrial, and riverine sources. MPs have been documented in local sediments, plankton, fishes, and even bottlenose dolphins, but shark exposure remains uncharacterized. Because sharks occupy high trophic positions, exhibit species-specific feeding strategies (pelagic, demersal, omnivorous), and possess a conserved vertebrate immune and oxidative stress system, they represent ideal sentinels for evaluating MP bioaccumulation and associated physiological effects.

To examine the trends regarding microplastic uptake and stress, we will be 1) performing plastic extraction from various tissues and comparative quantification both within tissues and across trophic guilds through chemical imaging and 2) correlating the comparative plastic load across species to known markers of toxicological stress like antioxidant enzymes and inflammatory biomarkers. These goals are intended to inform conservation strategies and address the knowledge gap on how environmentally relevant MP levels may negatively affect large vertebrates. We hypothesize that demersal feeders will exhibit higher MP burdens than pelagic species due to greater benthic contact and ingestion of sediment-associated prey, and that increasing MP load will correspond with elevated oxidative stress and inflammatory activation in liver and blood tissues.

2.03.P-Th010 How Microplastic Polymer, Size, and Shape Drive Toxicity in Tubifex tubifex

Simran Hansra[1], Ryan Prosser[2] and Chelsea Rochman[1] (1)University of Toronto, (2)University of Guelph

Microplastics are a ubiquitous and multidimensional contaminant, varying both chemically by polymer type and additives and physically by particle shape, size, and volume. The possible mechanism(s) of effect of microplastic exposure is still largely unknown. One reason for this may be because most toxicity studies have not isolated for individual characteristics, which are relevant to the effect mechanisms. To address this gap, and to better inform risk assessments of microplastic, our objective is to conduct a series of ecotoxicological experiments to measure whether effects vary by polymer, size (i.e., volume), and/or shape using Tubifex tubifex, a freshwater oligochaete found in the Great Lakes. First, we isolated for polymer type by creating microfibers from three different material types (polypropylene, polyester, regenerated cellulose) of uniform size. Then, we isolated for volume by creating polypropylene microfibers at three size classes – varying in volume. Last, we isolated for shape by creating polypropylene microfibers, spheres, and fragments of uniform

volumes. In each experiment, we tested five concentrations of 100, 1000, 10,000, 100,000 and 1,000,000 particles per 50 mL sediment. Each test chronically exposed T. tubifex for 28 days and measured survival and reproduction as endpoints. We hypothesize that effect does vary among microplastic characteristics, with effects being both chemical and physical. This presentation will share the results of our study to date. This work will better inform microplastic risk assessment, as we employ a series of environmentally relevant concentrations, as well as study an understudied compartment (sediment) and particle type (microfibers).

2.03.P-Th011 Optomotor Behavior of Pimephales promelas Larvae as a Complementary Tool for Ecotoxicological Assessment

Alexandre Arenzon[1], Roger Brustolin[1] and Lucia Helena Ribeiro Rdrigues[1] (1)Federal University of Rio Grande do Sul (UFRGS)

Behavioral endpoints have gained increasing relevance in ecotoxicology because they may detect sublethal effects not identified by traditional mortality or growth-based assays. Although behavioral assessments are mentioned in Brazilian environmental regulations, standardized protocols for fish behavioral testing are still limited. This study proposes the use of the optomotor response of Pimephales promelas larvae as a complementary endpoint for ecotoxicological evaluation.

The study aimed to evaluate whether alterations in optomotor behavior could be detected after acute exposure to a reference toxicant and whether spatial analysis of organism distribution could improve the sensitivity of behavioral interpretation. Larvae aged 8 to 14 days were maintained for 48 h under conditions compatible with acute toxicity protocols and subsequently exposed in glass aquaria positioned in front of a monitor displaying moving black and white vertical stripes. Organism distribution was evaluated using four virtual quadrants (Q1–Q4), with positive response defined as the presence of organisms in Q1 and Q2. A minimum positive response of 90% was adopted as the validation criterion. 3,4-dichloroaniline (4 mg/L) was used as positive control due to its known effects on visual and motor functions.

Control organisms showed positive responses above 90% in two of the three assays performed. Organisms exposed to 3,4-dichloroaniline presented a significant reduction in positive response (79%; $p \leq 0.05$). Spatial analysis demonstrated a marked reduction in Q1 occupancy and a more homogeneous distribution among quadrants following exposure, suggesting impaired tracking of the visual stimulus and reduced precision of the optomotor response. One assay did not achieve the predefined validation criterion, reinforcing the need for additional standardization.

The results indicate that optomotor behavior may represent a sensitive and ecologically relevant sublethal endpoint for ecotoxicological assessment. In addition, spatial distribution analysis increased the sensitivity of behavioral interpretation compared to binary analysis alone. Following further validation, particularly with environmental samples, the proposed method may provide a low-cost and highly replicable complementary tool for aquatic ecotoxicology.

2.03.P-Th012 The Development of Marine Organism Fertilisation Tests Suitable for Use in Chemical Risk Assessment

Graham Merrington[1], Dean Leverett[1] and Tom Austin[2] (1)wca environment Ltd, (2)Haleon

Global chemical risk assessment regimes for the aquatic environment overwhelmingly focus on the ecotoxicity testing of freshwater organisms. While standardised methods for testing marine organisms exist, there is often a tendency (particularly in Europe) to avoid marine testing and instead utilise Assessment Factors applied to freshwater data to predict hazards to marine organisms from chemicals. The assessment of fertilisation success can be a rapid and sensitive approach to evaluating the potential for substances to cause population-relevant effects on reproduction in coastal marine invertebrate taxa, such as echinoderms, molluscs and annelid worms. While standardised methods are available for the assessment of fertilisation success in echinoderms and marine bivalves, these tend to be focused on screening or comparative assessments (e.g. between samples), and results are rarely utilised in chemical risk assessments such as the development of water quality threshold values or regulatory assessments.

In this presentation we will focus on work aimed at exploring options for improving such assays using three echinoderm species and an annelid worm. The pharmaceutical diclofenac was used as the reference substance in these tests since previous results for these species tested using diclofenac were available in the literature with which to compare our outcomes. Tests were expanded beyond the standardised guidelines (although attempts were made to adhere to them as far as possible and to utilise their proposed criteria governing test validity) to cover wide concentration ranges and to include chemical verification of exposure concentrations. In addition, amendment of the approaches in the standardised guidelines were also examined, such as:

i) Pre-exposure of adult animals used to generate gametes for the tests
ii) Extension of the fertilisation period
iii) Use of orbital shaking during the fertilisation period

We will present the outcome of our studies, and compare the results across studies and with existing published studies on the same species and endpoints using diclofenac. The advantages and limitations of the approaches applied will also be discussed.

2.03.P-Th013 Cytotoxic and Transcriptomic Effects of Triphenyl Phosphate and Tricresyl Phosphate on Rainbow Trout (Oncorhynchus mykiss) Liver Cell Line (RTL-W1)

Houda Hanana[1], Susanne Kraemer[1] and Magali Houde[1] (1)Environment and Climate Change Canada

Tricresyl phosphate (TCP) and triphenyl phosphate (TPP), widely used organophosphate flame retardants (OPFRs), have raised concerns due to their frequent detection in the environment and their potential adverse effects on aquatic organisms. In recent years, fish cell lines have emerged as promising alternative approaches to fish toxicity testing. Our objectives for this study were to evaluate the cytotoxicity of these OPFRs in the RTL-W1 cell line and to use RNA-sequencing to determine transcriptomic points of departure (tPOD) and identify impacted biological pathways. Benchmark dose (BMD) analysis resulted in tPOD mode (first mode of the gene-level BMD distribution) values of 0.57 and 0.1 mg/L for TPP and TCP, respectively, which were 35 and 135-fold lower than their respective EC50 values. Pathway analysis showed that both chemicals altered steroid biosynthesis, terpenoid backbone biosynthesis and protein processing in endoplasmic reticulum (ER) pathways, suggesting a disruption of lipid metabolism and the induction of ER stress. However, despite these few shared pathways, patterns of gene transcription were different between compounds. For TPP, the most

sensitive pathway was aminoacyl-tRNA biosynthesis (2.13 mg/L), whereas steroid biosynthesis (0.45 mg/L) was most sensitive for TCP. This suggests different modes of action with potential for TPP to impair amino acid translation and TCP to induce more prominent effects on energy and lipid metabolism in RTL-W1 cells. Further characterization is needed to enhance experimental accuracy, reliability, and predictivity of this in vitro method to adequately assess the potential environmental effects of these OPFRs.

2.03.P-Th014 Painted Lady Butterfly, Developing Methods for a More Representative Surrogate Species for Endangered Species Assessment

Melissa Harris[1], Twyla Blickley[2], Steve Hicks[2], Gavin Johnson[3], Yunjie Ding[3], Samantha Kagey[3] and Tamara Lunsman, Ph. D.[2] (1)Corteva Agricscience UK Limited, (2)Corteva Agriscience UK Limited., (3)Corteva Agriscience UK Limited

When assessing potential risk to pollinators from chemicals, honey bees are the predominant surrogate species for regulatory toxicity testing. However, in the United States (US), most endangered and threatened non-target arthropods are Lepidoptera (butterflies, moths, and skippers). The need for a new, more representative surrogate species for Lepidopterans has been of interest with the listing of the monarch butterfly (Danaus plexippus) as endangered in Canada and potential listing as threatened in the US.
To address this data gap, the painted lady butterfly (PLB, Vanessa cardui) was evaluated as a surrogate Lepidopteran species. This species provides several practical advantages, including fewer testing restrictions, ease of laboratory rearing, and biological relevance to monarchs. An acute contact toxicity assay was developed and validated using insecticides and fungicides with various modes of action. LD50 values from PLB were compared to reported honey bee values to determine alignment between the two species. Data collected shows that PLB can be a reliable surrogate for assessing agrochemical toxicity in Lepidoptera, thus providing a more accurate risk assessment for non-target Lepidopteran species.

2.03.P-Th015 Establishment and Validation of a Northern Hyalella azteca Culture for Regionally Relevant Toxicity Testing in Low-Ionic Strength Systems

Stephanie Walsh[1], Samantha Jarron[1] and Matthew Bond[1] (1)Canadian Nuclear Laboratories

Standardized laboratory strains of Hyalella azteca are widely used in freshwater toxicity testing; however, these organisms are typically cultured under water conditions that may not reflect the low-ionic strength aquatic environments typical of northern Canadian systems. This discrepancy introduces uncertainty when extrapolating laboratory results using the standardized strain to predict wild population responses to site-specific environmental risk assessments, particularly for low-ionic strength, mining-influenced regions of Canada.

To address this gap, a wild population of Hyalella azteca was collected from a low-ionic strength lake in northern Saskatchewan and successfully established under laboratory conditions using a new standard artificial medium closely matching the field ionic strength (~3.5 × 10-4 mol·L-1). The population's performance was evaluated and verified by successful survival and sustained reproduction. Genetic characterization confirmed that the population belongs to Clade 1 of the Hyalella azteca complex, with evidence of within-clade genetic structuring. The culture demonstrated consistent sensitivity in 96-h potassium chloride reference toxicity tests (LC50 = 132.6 ± 18.8 mg·L-1; n = 6; ≥90% control survival). Preliminary application of the culture in polonium-210 aqueous exposure experiments further demonstrates the culture's suitability for radionuclide

toxicity testing under environmentally representative water chemistry conditions.

This approach shows that regionally derived Hyalella azteca cultures can be successfully established and validated under low-ionic strength conditions, improving ecological relevance of toxicity testing and supporting accurate risk assessments in freshwater environments. Furthermore, it enables toxicity assessments using organisms and media that are reflective of freshwater systems in northern Canada that may be impacted by technologically enhanced naturally occurring radioactive materials.

Disclaimer/Disclosure: This work was funded by Atomic Energy of Canada Limited's Federal Nuclear Science and Technology Work Plan.

2.03.P-Th016 Ecotoxicity Assessment of UV Filters Using Corals and Symbiotic Dinoflagellates

Rie Tai[1], Hiroyuki Mano[1] and Wataru Naito[1] (1)National Institute of Advanced Industrial Science and Technology (AIST)

Ultraviolet (UV) filters are widely used in sunscreens and other personal care products to protect human skin from solar radiation. After use, these compounds can enter coastal waters via domestic wastewater or direct release during recreational activities. Their increasing production and use have raised concerns about potential ecological effects on coral reef ecosystems. In Japanese subtropical waters, which are connected to the Coral Triangle via the Kuroshio Current, ecotoxicity data relevant to native reef organisms are still limited.
This study aims to evaluate the effects of representative UV filters on corals and symbiotic dinoflagellates that support reef ecosystems. Ecotoxicity test protocols were developed for the reef-building coral Acropora digitifera and its symbiotic dinoflagellates, and these methods were applied to assess the toxicity of selected UV filter ingredients.
This presentation will describe the test protocols and present toxicity test results for A. digitifera and symbiotic dinoflagellates exposed to selected UV filter ingredients.

2.03.P-Th017 Use of Mesocosm Endpoints in Refining Aquatic Risk Assessment: Learnings From Across the Pond

Daniel Pickford[1] and Pria Mahabir[2] (1)Syngenta Ltd, (2)Syngenta Crop Protection AG

Experimental ecosystem (mesocosm or microcosm) studies are a valuable refinement tool in aquatic risk assessment for plant protection products (PPPs), accommodating environmental fate and behaviour of the active substance while addressing ecological processes such as community level effects and recovery. These processes occur in real world edge-of-field surface waters, and in the EU risk assessment paradigm mesocosms are considered the surrogate reference tier, supporting prediction of risks to aquatic flora and fauna arising from intended uses of PPPs. In spite of increased interest in the utility of mesocosms in North America, recent years have seen a decline in the conduct of mesocosms in support of European registration of PPPs and this reflects the increased uncertainty around their acceptance for higher tier risk assessment by EU regulators. Key issues include the opportunity to use a recovery endpoint (No Observed Ecologically Adverse Concentration), representativeness of the community in the cosms, demonstration that the exposure profile used in the study is sufficiently worst case, how to integrate data from multiple studies, what magnitude of assessment factor is

appropriate, and failure to consider effects at community level. Examples will be provided from mesocosms conducted with the pyrethroid insecticide lambda-cyhalothrin and submitted in EU registration processes, which demonstrate the robustness and consistency of higher tier endpoints derived from mesocosm studies.

Critical Minerals in a Warming World: Balancing Demand, Ecosystem Health and the Green Transition

2.04.T-01 Assessing the Impacts of Rare Earth Elements in Northern Environments

Mustajab Khalid[1], Lauren Best[1], Jane Morgan[1], Ravleen Kaur[1], Alexis Dimitropoulos[1], Andrew Thompson[1], Jim McGeer[1] and Erin Leonard[1] (1)Wilfrid Laurier University

Rare earth elements (REEs) are a group of metals recognized as critical to Canada's future due to their applications in modern technologies. Increased mining efforts has raised concern of potential environmental impacts, particularly for northern ecosystems. There are no environmental quality guidelines for REEs. EQGs will be strengthened by acute and chronic toxicity testing and describing toxicity modifying factors (TMFs) that influence metal complexation and competition interactions described by the Biotic Ligand Model (BLM). This research investigates effects of REEs, neodymium (Nd) and yttrium (Y), on Arctic charr (Salvelinus alpinus) and rainbow trout (Oncorhynchus mykiss) to understand their sensitivity and how TMFs influence bioavailability and accumulation. Exposures were flow-through, in soft water (~15 mg CaCO3/L), at 10.3˚C (n = 8), for 15 hours. Gill bioaccumulation was transport-mediated for both Nd and Y, with gill accumulation showing a concentration-dependent increase that approached a maximum as binding sites became saturated. TMF treatments including 16 mg Ca/L or 2 mg/L dissolved organic matter significantly reduced gill bioaccumulation. Gill Nd accumulation exhibited a maximum bioaccumulation of 6.08 µg Nd/g wet wt. (95% C.I. 5.31 – 6.84) and Km (affinity) of 10.9 µg Nd/L (95% C.I. 5.45 – 16.3). Km increased to 69.4 µg Nd/L (95% C.I. 42.1 – 96.6) with Ca (6.4 x reduction), and 87.2 µg Nd/L (95% C.I. 48.3 – 126) with DOM (8.0 x reduction). Additionally, 7-day acute toxicity trials were conducted to assess species-specific sensitivity to Y in larval S. alpinus and O. mykiss. Larvae were exposed to a 0 - 10,000 µg/L Y gradient, where rainbow trout bioaccumulated Y at concentrations higher than 2,229 µg/L, and exhibited an LC50 of 2,339.3 µg/L (dissolved) at a hardness of 80 mg/L as CaCO3. By comparison, Arctic charr bioaccumulated Y at 1,710 µg/L but there were no significant mortalities. Whole-body ions (Ca, Mg and Na) remained unchanged relative to controls in both species, suggesting that acute Y exposure does not alter ion homeostasis. These findings demonstrate gill Nd and Y uptake follows BLM principles: saturable kinetics with both cationic competition and DOM complexation reducing bioavailability and charr are less sensitive than rainbow trout. This understanding of REE bioavailability will contribute to the development of site-specific WQGs for Nd and Y that are culturally and ecologically important for northern fish species.

Disclaimer/Disclosure: NSERC Alliance Grant - ALLRP 607562 - 25.

2.04.T-04 The Effects of Elevated Temperatures and Copper on the Development and Performance of Whitefish

Andrew Thompson[1], Natalie Nykamp[1], Johann Memmel[1], Anne Cremazy[2], Tamzin Blewett[3] and Erin Leonard[1]
(1)Wilfrid Laurier University, (2)National Institute for Scientific Research (INRS), (3)University of Alberta

To meet increased demand for copper, prospects have earmarked mining in Arctic regions. Limited studies have characterized the sensitivity of Arctic fish species particularly at early-life stages. The Arctic region is warming at an accelerated rate due to climate change, necessitating the exploration of copper impacts in current and future warming scenarios. We tested the hypothesis that whitefish, a key aquatic species in Arctic habitats, would be more sensitive to copper exposures at elevated temperature. Whitefish were exposed from 1-day post-fertilization to environmentally relevant concentrations of 0-160 µg/L copper, at either 1 or 6°C. Fish were held in these conditions until hatch and just prior to yolk sac absorption, and samples were taken for molecular assessments, morphology, and copper accumulation. Additionally, larvae near yolk sac absorption were assessed for thermal and hypoxia tolerance. Copper accumulated more in colder fish, but copper itself did not increase mortality. Copper led to earlier hatch, smaller fish at hatch for fish exposed to low concentrations of copper, and perturbed eye growth at the highest copper concentrations. During yolk sac consumption, control fish appear to grow larger relative to copper exposed fish. Molecular assessments demonstrated interesting trends in markers of stress. Hypoxia tolerance is reduced with increasing copper level, but only in fish that were reared at colder temperatures. Copper exposure reduced thermal tolerance regardless of developmental temperature. Together, these results suggest that whitefish are sensitive to copper exposure at environmentally relevant levels, with limited performance impacts of future warming scenarios.

2.04.T-05 Development of a Multi-Resource Framework To Support Holistic Natural Resource Development and Post-Development Restoration Decisions

Daniel Jones[1], Kate Campbell[1], Stephanie Gordon[1], Brian Reichert[1], Bethany Straw[1] and Brianna Williams[1]
(1)U.S. Geological Survey (USGS)

Natural resources including critical minerals, energy resources, and open natural lands are critical to modern life and often co-occur, leading to difficult management decisions. These decisions are further complicated by overlapping jurisdictional, regulatory, and cultural boundaries each with their own priorities, monitoring, and reporting requirements. The U.S. Geological Survey (USGS) has begun to develop a multi-resource decision-support framework and suite of tools (including online mapping and report generation applications) to provide actionable science information critical to these management decisions. The framework has application to both resource development and post-development restoration, incorporating regulatory and permitting requirements to ensure scientific information is actionable and transparent throughout the decision-making process. USGS has a long history of providing foundational science resources and data, but these data are often not easily accessible or transferrable to regulatory or permitting workflows. The multi-resource framework and tool development efforts seek to synthesize existing datasets to understand data and information gaps, guide new data collection efforts, and identify potential opportunities for hazard mitigation, restoration, and economic benefits throughout the resource development and restoration life cycle. The outcomes of these efforts have application to both inform future science directions related to natural resources and for resource managers to guide real-time management decisions. This talk will provide a high-level overview of the ongoing framework and tool development activities with emphasis on critical minerals at case study (Appalachian Mountains) and

national-scale (U.S.) implementations.

2.04.T-06 Acute Copper Exposure Improves Critical Thermal Maximum and Reduces Feeding of Juvenile Lake Whitefish (Coregonus clupeaformis)

Sabrina St-Hilaire[1], Andrew Thompson[1], Anne Cremazy[2], Tamzin Blewett[3] and Erin Leonard[1] (1)Wilfrid Laurier University, (2)National Institute for Scientific Research (INRS), (3)University of Alberta

Copper (Cu) is a well-known toxicant in aquatic ecosystems and is a growing risk in the Canadian Arctic. Cu mining is proposed to increase in Northern Canada over the coming decades, as the Critical Minerals Strategy deems Cu as a priority metal necessary for economic growth. Although Cu has many economical uses, Cu toxicity has been shown to impact fish behaviour and thermal tolerance. Cu mining effluent may pose a threat to aquatic organisms, especially in combination with multiple stressors such as changes in temperature and oxygen. Lake whitefish (Coregonus clupeaformis) are a culturally important species with a habitat range from the Great Lakes to central Nunavut. Critical thermal maximum (CTmax) is a measure of thermal tolerance, measured as the temperature at which a fish loses equilibrium, and can be used to assess the responses of aquatic species to climate change. Previous studies have shown that chronic Cu exposure reduced CTmax in lake whitefish and was dependent on developmental stage. The present study aims to assess the thermal tolerance, feeding, and behavioural responses of juvenile lake whitefish in response to acute (4-day) Cu exposure. Results showed improved thermal tolerance with increasing concentrations of Cu after a 4-day acute exposure, noted by a 1.6 ºC increase in CTmax at 150 µg/L Cu, compared to controls. Previous literature has shown that improved thermal capacity in fish after Cu exposure may be due to an increase in blood oxygen delivery to tissues, and that a primary stressor, such as Cu, may enhance the ability of fish to cope with a secondary stressor, e.g., temperature. Results from the feeding trial showed that Cu exposed fish consumed significantly less brine shrimp than controls, potentially pointing to impairments to detection of food or the drive to eat. Patterns of tissue bioaccumulation and behavioural responses aligned with ecological performance measures, indicating that Cu exposure impacts multiple aspects of fish performance. These results highlight the complexity of multiple stressors, and the need to carry out performance tests to understand potential ecological implications of toxicant exposure. While CTmax provides a valuable measure of acute thermal capacity, further studies with prolonged duration would improve our understanding of the effects of Cu and thermal stress on juvenile fish.

Disclaimer/Disclosure: NSERC Alliance Grant ALLRP 586710-2023

Critical Minerals in a Warming World: Balancing Demand, Ecosystem Health and the Green Transition

2.04.P-Tu101 Evaluating Ecological Risks of Dust Deposition From a New Critical Minerals Mining Project

Tim Verslycke[1] and Sarah M. Zahn[1] (1)Gradient

Critical mineral mining can potentially affect ecosystems through land-use change and habitat loss, waste generation, dust emissions, and impacts to surface water and groundwater. As demand for critical minerals

accelerates to support the renewable energy transition, careful consideration of ecological impacts is important – especially where climate change and loss of biodiversity may be amplifying mining-related impacts. At the same time, information on the mobility, bioavailability, and ecological toxicity of critical minerals is often limited, further complicating the assessment of ecological risks for new critical minerals mining projects. This presentation illustrates how a weight-of-evidence risk assessment approach and uncertainties associated with each line of evidence were used to develop robust ecological risk conclusions for a new critical minerals mining project.

This presentation describes an ecological risk assessment of dust deposition for the Hermosa Mine Development Project in Santa Cruz County, Arizona. The Hermosa project could produce five minerals designated as critical by the US federal government, including zinc and manganese. The assessment focused on potential effects of project-related dust emissions and deposition on two federally listed plant species, Bartram's stonecrop (Graptopetalum bartramii) and beardless chinchweed (Pectis imberbis). Multiple lines of evidence were integrated, including site-specific air quality and dust deposition modeling; project-specific environmental protection measures; metals concentrations in dust source materials; geospatial data on plant populations; species-specific habitat and biological information; background metals concentrations; vegetation toxicity thresholds; and information on metal bioavailability, essentiality, bioaccumulation, and species sensitivity. Together, these data were used to characterize risk, evaluate uncertainty, and support clear risk communication. The approach provides a framework for evaluating and communicating ecological risks of critical minerals mining projects in light of uncertainties associated with climate-related stressors.

2.04.P-Tu102 Assessing Early Life Stage Toxicity of Arctic Relevant Fish Species to Copper

Natalie Nykamp[1], Sabrina St-Hilaire[1], Andrew Thompson[1], Anne Cremazy[2], Tamzin Blewett[3] and Erin Leonard[1]
(1)Wilfrid Laurier University, (2)National Institute for Scientific Research (INRS), (3)University of Alberta

Copper (Cu) is an aquatic contaminant that enters Canadian waterways from multiple anthropogenic inputs, including mining. Recently, Canada released its Critical Mineral Strategy outlining a list of minerals that are proposed to drive Canadian economic growth, for the use of green technologies. Cu is initially prioritized for Canadian supply chains and will be one of the main focuses of federal investments, with recent investments in Arctic infrastructure facilitating the development of Cu mines in Nunavut. The Canadian government has Federal Environmental Quality Guidelines (FEQGs) intended to protect aquatic life from contaminants such as Cu, although these guidelines are mainly derived from temperate species. There is little known about the sensitivity of Arctic species, which have longer periods of development, lower metabolic rates, and slower detoxification, which may lead to differential sensitivity compared to temperate models. This project aims to assess Cu toxicity in Arctic organisms and address the uncertainty surrounding the effectiveness of current FEQGs for the protection of Arctic species. The sensitivity of two Arctic fish species, that are currently not included in FEQGs, to Cu was assessed. At 1 day post-hatch, Arctic char (Salvelinus alpinus) and Lake whitefish (Coregonus clupeaformis) were exposed to 8 concentrations of Cu (0-640 µg/L) at 5ºC, and mortalities were observed over 7 days. Larvae were then sampled for whole body bioaccumulation and morphological analysis. Preliminary results show that the 7-day LC20 for larval Arctic char is 121 ± 7.28 µg/L and for larval lake whitefish is 494 ± 14.9 µg/L based on dissolved Cu. Compared to other species of fish reported in the FEQGs, these Arctic fish are shown to be more tolerant to Cu than all of the reported species.

However, published test temperatures were higher, 12-25ºC, while these tests were done at 5ºC. Measurements of bioaccumulation were made to understand the linkage between mortality and copper exposure. Further, we quantified morphology of larvae following the 7-day exposure, to understand whether sublethal dosages of Cu could impose changes to growth. Together, this study will provide critical toxicity data regarding Arctic relevant models, further bringing forward markers of sub-lethal toxicity, in support of FEQGs that can encompass the diversity of species found in Canada.

Disclaimer/Disclosure: NSERC Alliance Grant ALLRP 586710-2023

Ecotoxicology and Management of Bivalves

2.05.T-01 Examining the Transcriptomic and Microbiome Profile of Eastern Oysters in Response to a Waterborne Exposure of Perfluorohexanoic Acid (PFHxA)

Jessica Donaldson[1], Shisbeth Tabora Sarmiento[1], Estrella Maldonado[1], Mackenzie Connell[1], tracie baker[1], Lauren Blackman[1], John Bowden[1] and Joseph Bisesi[1] (1)University of Florida

Per- and polyfluoroalkyl substances (PFAS) are a large group of anthropogenic chemicals used heavily in commercial goods due to their chemical properties. However, these same properties make them extremely mobile, persistent, and resistant to breakdown in the aquatic environment. There is a substantial gap in understanding the toxicity profile of short-chain PFAS in exposed aquatic organisms. In addition, research has focused largely on the effects of PFAS in model organisms. Non-model, commercially, and environmentally important aquatic organisms are vital to assess potential PFAS toxicity to best protect these vulnerable populations. To address these data gaps, the study aims to evaluate the transcriptomic and microbiome profile in eastern oysters (Crassostrea virginica) following exposure to Perfluorohexanoic acid (PFHxA). Oysters were exposed to 200 ng/L, and 2000 ng/L of PFHxA via waterborne exposure for 28 days. Following exposure, the hepatopancreas was processed for mRNA and libraries were prepared for RNA-seq analysis. For the microbiome analysis, the gills were processed and libraries were prepared for Illuminia 16s sequencing. iPathways (Advaita Corporation, Anne Arbor, Michigan) was used for Gene Set Enrichment Analysis and Qiime 2 will be used for microbiome assessment. There were notables DEGs associated with bivalve lipid metabolism altered specifically NPC1 and CHRAC1 was upregulated at both doses. Innate immune effects and stress response was also identified to be potentially affected with notable genes identified following 200 ng/L exposure, specifically effects to the autophagy pathway and apoptotic effects. Microbiome analysis is still underway, but it is hypothesized that there will be increases in pathogenic microbes in exposed bivalves further suggesting PFHxA may impact the innate immune system in bivalves. This study will be the first to examine sub-chronic waterborne exposures to PFHxA and the resulting impacts on the transcriptome and microbiome in eastern oysters.

2.05.T-02 Imidacloprid Accumulation and Immune Response in the Eastern Oyster, Crassostrea virginica

Risa Cohen[1], Lisa Brown[1], John Carroll[1] and Daniel Gleason[1] (1)Georgia Southern University

Neonicotinoid pesticides are used extensively worldwide for agriculture, residential applications, and invasive

species control on land; yet growing evidence indicates that marine invertebrates are inadvertently harmed by these products. Declines in the Eastern oyster, Crassostrea virginica, are especially problematic because in addition to commercial value, reefs built by Eastern oysters provide ecosystem services, including the formation of complex habitats utilized by numerous marine species, improved water quality through filtration, shoreline stabilization, and aesthetic value. It is currently unclear whether neonicotinoids pose a threat to C. virginica, therefore we examined oyster responses to imidacloprid, the most used neonicotinoid globally, in one of four concentrations ranging from 0-1 mgL-1 in the laboratory. Following a 4-week exposure, oysters were either measured for tissue imidacloprid accumulation using Liquid Chromatography-Mass Spectrometry (LC-MS) or subjected to an immune challenge assay to determine whether imidacloprid exposure influenced their ability to defend themselves against opportunistic pathogens. Oysters were either injected with a known pathogen Vibrio splendidus (infection), sterile seawater (control) or received no injection (naïve). After 24 hours, hemolymph was collected for subsequent immune gene analysis. There was a trend towards differences in expression of a defensin gene (BigDef), an antimicrobial peptide, suggesting that the oysters became more susceptible to Vibrio infection as imidacloprid concentrations increased. Tissue imidacloprid concentration also increased with exposure concentration, indicating a need for widely accessible monitoring methods. To evaluate commercial Enzyme-Linked Immunosorbent Assay (ELISA) as a method for imidacloprid detection, a second 4-week exposure experiment was conducted. Oysters were exposed to the same concentrations as the first experiment, then tissues from each replicate were divided for analysis using both LC-MS and ELISA. Tissue imidacloprid concentration analyses are expected to be positively related to exposure concentration using both methods. That imidacloprid accumulates and induces immune responses in Eastern oysters supports investigation of ELISA as a potential technique to improve management of recreational and hatchery oyster harvests.

2.05.T-03 Fate and Effects to the Benthic Community of a Multi-Year Copper Treatment To Eradicate Invasive Mussels in a Large Western River, USA

Austin Baldwin[1], Erin Murray[1], Lauren Zinsser[1], Tyler King[2], Scott Ducar[2], India Southern[3], Theresa Thom[4] and Chris Mebane[1] (1)U.S. Geological Survey (USGS), (2)U.S. Geological Survey, (3)Idaho Department of Environmental Quality, (4)U.S. Fish and Wildlife Service

Copper-based chemical treatments are commonly used to eradicate invasive mussels in small ponds and lakes, but their use in large rivers has been limited. In 2023, in response to a detection of invasive quagga mussels, a 10-kilometer reach of the Snake River (Idaho, USA), was treated with an unprecedented 19,300 kg of chelated copper molluscicide to a target concentration of 1,000 µg/L for 10 days. This treatment was repeated and expanded in 2024. We assessed the transport and fate of the copper and its exposure and effects on the non-target benthic community downstream. Water samples were collected at seven locations throughout the 2023 treatment period, and bed sediment, periphyton, and benthic macroinvertebrates were collected at six to seven locations pre- and post-treatment in 2023 and 2024. In 2023, nearly half of the original mass of copper was removed from the water column via sedimentation, sorption to algae, or biological uptake within the 10-km treatment reach and the first 15 km downstream. Even so, dissolved copper concentrations exceeded the acute toxicity threshold at least as far as 28 km downstream for more than two weeks. Bed sediment copper increased by up to 8.3-fold following the 2023 treatment and up to 25-fold following the 2024 treatment (relative to initial, pre-treatment 2023 concentrations) due to interannual accumulation and an increase in the amount of copper used in 2024. Effects on benthic macroinvertebrates varied by taxa. From 0-28 km downstream of the treatment reach, invertebrate abundances decreased 52-94% following the 2023 treatment, with gastropods

among the most affected. Of the unique taxa present at these sites pre-treatment, 52-64% were not found post-treatment, but were replaced by other taxa, indicating a reorganization of the base of the food web. Additionally, from 0-15 km downstream, the percentage of individuals from tolerant taxa increased 2 to 15-fold after the 2023 treatment. Findings from this study can help watershed managers plan future invasive mussel eradication responses while protecting culturally, economically, and ecologically important non-target species in large rivers.

2.05.T-04 Examining the Effect of Complex Contaminant Mixtures on Freshwater Mussels Using Lab and Field Studies

Patricia Gillis[1], C. James Bennett[2], Erika Burton[2], Lisa Hoard[2], Jenna Anderson[2], Adrienne Bartlett[1], Gerald Tetreault[1], Shirley Anne Smyth[1] and Mark Hewitt[1] (1)Environment and Climate Change Canada (ECCC), (2)Environment and Climate Change Canada

Compared to other biota, native freshwater mussels, particularly the early-life stages have a heightened sensitivity to waterborne contaminants. Field studies can identify habitats where mussel populations are affected by poor water quality, and laboratory studies can identify which species and life stages are the most sensitive to contaminants. In this project we combined lab-based endpoints with field-based observations to investigate how complex contaminant mixtures affect freshwater mussels in a watershed affected by multiple point and nonpoint stressors. This work focused on a series of sites that bracket a wastewater treatment plant on the main stem of the Grand River (Brantford, Ontario, Canada) and another series of sites that bracket an industrial discharge on a nearby tributary (Boston Creek). For the laboratory component, surface waters from each site, as well as final treated wastewater effluent and untreated landfill leachate associated with the study area were collected multiple times in 2024 and 2025. Using standard methods, acute toxicity tests with Lampsilis fasciola glochidia (mussel larvae) were conducted with undiluted site waters as were exposures with serial-diluted wastewater effluent and landfill leachate. For the field component, richness, abundance, and size structure of the freshwater mussel population at each site was examined using semi-quantitative, time-based visual searches. Overall, the surface waters from the main stem had minimal effects on the viability (survival surrogate) of exposed glochidia, although some seasonal variability was observed. However, surface waters collected immediately downstream of an industrial outfall (gypsum plant) on a tributary exhibited toxicity, with viability recovering in waters collected further downstream. Regarding wild mussels, there was a trend towards fewer live mussels downstream of both point sources compared to immediately upstream, however differences in habitat may be a contributing factor. This investigation is part of a broader study, the Integrated Chemicals Mixtures Project where fish and other invertebrates (snails, amphipods, mayflies) have been exposed to and/or collected from the same sites and effluents. The broader project also includes ongoing targeted and nontargeted chemical analysis, with a goal of identifying which components of the studied complex chemical mixtures are associated with observed effects, including those in lab-exposed and wild mussels.

2.05.T-05 Impact of a Biofuel Spill on the Mytilus edulis and Placopecten magellanicus Gaping Behavior in Winter Conditions

Guillaume Durier[1], Carolanne Ducasse[2], Delphine Veillard[1], Suzie Severino[2], Mariane Caplette[3], Camille Berthod[3], Réjean Tremblay[1] and Richard St-Louis[3] (1)Institut des sciences de la mer, (2)University of Quebec at Rimouski (UQAR), (3)UQAR

Regulations aimed at reducing the environmental impact of maritime transport are encouraging the sector to adopt alternative fuels such as biofuels. Produced from biomass, these fuels may have different effects on marine fauna than petroleum-based fuels in the event of an accidental spill. It is therefore important to investigate their impacts in order to better anticipate the environmental consequences of such events. As Canada experiences winter conditions during a large part of the year and few studies have been conducted under such conditions, we chose to simulate a spill under winter conditions. During the winter of 2026, blue mussels (Mytilus edulis) and giant scallops (Placopecten magellanicus) were exposed to two biofuels, B100 (FAMEs) and Hydrotreated Vegetable Oil, in an outdoor mesocosm designed to reproduce realistic winter environmental conditions mainly for the seawater temperature. As demonstrated in previous studies, the blue mussel is a particularly relevant sentinel species for detecting pollution through its gaping behavior. It may therefore serve as an indicator of potential toxicity associated with these biofuels. The sea scallop, on the other hand, is a more sensitive species displaying a different gaping behavior, characterized by a nearly continuous valve opening related to its ecology. Its exposure therefore provides a relevant complement to the blue mussel model because of this sensibility and a different behavioral response to stress (valve closure for mussels and clapping for scallops). Comparisons of valve behavior between biofuel-exposed groups and an unexposed control group were used to identify potential behavioral changes associated with exposure. In addition, biomarker analyses related to cellular toxicity, DNA damage, and the presence of biofuels in tissues were performed to assess the toxicity of these fuels. Combining these results with valve behavior observations will help determine whether the bivalves were able to detect the contaminants or whether these compounds were bioaccumulated in the organisms.

2.05.T-06 Multi-Stressors in Southern California Bight Bivalves: Spatial Patterns and Risk Assessment

Alvine Mehinto[1], Jayme Smith[1], Charles Wong[1], Joshua Steele[1], Victoria McGruer[1] and Ken Schiff[1] (1)Southern California Coastal Water Research

The Southern California Bight (SCB) is a highly urbanized coastal region subject to multiple anthropogenic stressors, yet comprehensive assessments integrating these different stressors in coastal food webs remain limited. Here we present findings from a large-scale monitoring effort examining the occurrence, spatial and seasonal distribution of chemical contaminants, harmful algal bloom (HAB) toxins and pathogens in bivalves collected from multiple sites across over three seasons. Mussels and oysters were analyzed for (1) inorganic elements, legacy organochlorine compounds, and perfluorinated compounds, (2) domoic acid, microcystins, and yessotoxin, and (3) pathogens. Chemical contaminants showed no seasonal patterns. But spatial patterns were observed for mercury, chlordanes, DDTs, and PCBs, with higher concentrations measured in locations with intensive human activity. PCBs was the only analyte class exceeding California Advisory Tissue Levels (ATLs), with 15% above the ATL for no more than three servings per week. For algal toxins, domoic acid was consistently detected at low concentrations, remaining below U.S. FDA regulatory thresholds. Microcystins

were frequently detected in both species, with exceedances of California's health-based guidance threshold in 12.5% of mussel samples and 40.6% of oyster samples, particularly during summer. YTX was commonly detected in mussels but always at low concentrations. Critically, co-occurrence of multiple toxins was observed in most samples indicating that multi-toxin exposure is a recurring feature of the SCB coastal food web, even in the absence of acute bloom events. Among the pathogens, norovirus was detected in less than 15% of samples with some exceedances to existing EU FSA thresholds. Together, these findings reveal that bivalves in the SCB serve as vectors of concurrent exposure to diverse stressors. This study also highlights the need to integrate different stressors to understand relative and cumulative exposure risk to both human and ecological health.

Ecotoxicology and Management of Bivalves

2.05.P-We039 The Invasive Zebra Mussel (Dreissena polymorpha) as an Indicator Species for Microplastic Pollution in Freshwater (River Thames, UK)

Stephanie Andrews[1], Ceri Lewis[1] and Tamara Galloway[1] (1)University of Exeter

Mussels are widely used as bioindicators for a range of aquatic pollutants. The zebra mussel (Dreissena polymorpha) is an invasive species to the River Thames, UK ecosystem and presents a threat to native mussel species (Unio spp.) First, this study set out to examine the microplastic loading in both native Unio spp. and invasive zebra mussels. Comparison between species revealed significantly higher microplastic abundance in zebra mussels (0.97 ± 0.26 Mp/g and 0.84 ± 0.18 Mp/g) than Unio spp. (0.10 ± 0.01 Mp/g and 0.11 ± 0.02 Mp/g) when results were expressed per g tissue than per individual. Secondly, it aimed to assess the use of the zebra mussel as an indicator of microplastic pollution in freshwater environments. Zebra mussels were collected and depurated for 48 h in filtered river water, after which a significant decrease in microplastic abundance within mussel tissue was observed. Mussels were deployed into surface and bottom cages, at two locations in the river, for a period of seven days. Microplastic contamination in surface deployed mussels increased from 0.76 ± 0.15 Mp/ g to 1.10 ± 0.22 Mp/ g and bottom mussels 0.82 ± 0.15 Mp/ g to 1.68 ± 0.25 Mp/ g during deployment. Average microplastic abundance in surface water was 0.53 ± 0.09 Mp/ litre and 0.43 ± 0.09 Mp/ litre in bottom water. Microplastic abundance in mussel tissue and river water showed a positive correlation, indicating zebra mussel microplastic uptake closely corresponds to microplastic loading in the water column. Irrespective of site or depth, polymer analysis revealed cellulosic particles were most abundant in mussel tissue, whilst polyester was most abundant in water samples. The findings of this study highlight the presence of microplastics in both native and invasive mussel species in the River Thames and demonstrates the potential of zebra mussels as an indicator species for microplastic pollution in freshwater environments.

2.05.P-We040 Archived Dreissenia Mussels As Bioindicators of Spatial and Temporal Microplastic Contamination in the Laurentian Great Lakes

Jardine Lam-Colling[1], Jordan Musetta-Lambert[2], Jordyn Broadbent[3] and Ryan Prosser[1] (1)University of Guelph, (2)Environment Climate Change Canada (ECCC), (3)Environment and Climate Change Canada (ECCC)

The Laurentian Great Lakes represents one of the world’s largest freshwater systems and provides critical ecological, economic, and drinking water resources for millions of people. However, microplastic

contamination has become an increasing concern in freshwater systems such as the Great Lakes, where urban activity, wastewater inputs, and plastic pollution may threaten water quality and aquatic organisms. Despite growing attention to microplastics, assessing the spatial and temporal patterns of microplastic contamination remains challenging across large and complex freshwater systems. This study investigates whether dreissenid mussels (Dreissenia polymorpha and Dreissenia bugenisis) can effectively act as bioindicators of microplastic distribution across multiple years and locations within the Great Lakes Basin. Archived mussel samples collected from multiple sites and years are used to assess spatial and temporal variation in microplastic contamination. Tissue from individual mussels were chemically digested to isolate suspected microplastic particles which are visually quantified and characterized according to morphology, colour, and size. A subset of particles was analyzed using Fourier transform infrared spectroscopy to confirm polymer identity. Microplastic abundance and particle characteristics were compared across sites and sampling years to identify potential differences in contamination patterns across the Great Lakes. Comparisons of microplastic abundance, particle morphology, and polymer composition across sites and sampling years will be used to identify the presence of spatial and/or temporal patterns of contamination within the Great Lakes. This study will provide insight on whether dreissenid mussels can be used as bioindicators for long-term monitoring of microplastics.

2.05.P-We041 Current Practices and Challenges in Dreissenid Mussel Management

Shisbeth Tabora Sarmiento[1] and Joseph Bisesi[1] (1)University of Florida

Invasive dreissenid mussels, including zebra mussels (Dreissena polymorpha) and quagga mussels (Dreissena rostriformis bugensis), continue to cause significant ecological and economic damage across freshwater systems in North America. While a growing body of research has evaluated the efficacy of various control strategies, comparatively little is known about how these approaches are actually implemented in the field. Understanding the real-world experiences of water managers and practitioners is essential to bridging the gap between experimental evidence and operational practice. This study presents findings from a survey of practitioners across U.S. managing dreissenid mussel invasions in diverse water systems, with varying levels of experience and infestation scales. The survey assessed impacts of mussel invasions at each managers site, current use of chemical, physical, and biological control strategies, treatment frequency, monitoring practices, and perceived effectiveness for both adult mussels and veligers. Key challenges such as cost, regulatory constraints, recolonization, and non-target impacts were also examined, along with the factors that would facilitate adoption of new approaches. This study aims to reveal important insights into the disconnect between what research recommends and what is feasible in operational settings. Barriers to implementation are identified alongside opportunities for stronger researcher-practitioner collaboration. This practitioner-centered perspective complements the existing experimental literature and contributes to the development of management strategies that are scientifically sound and operationally viable for those managing these invasions.

2.05.P-We042 Managing Invasive Mussels: A Scoping Review of Dreissenid Control

Shisbeth Tabora Sarmiento[1], Courtney Pyche[1] and Joseph Bisesi[1] (1)University of Florida

Zebra mussels (Dreissena polymorpha) and quagga mussels (D. rostriformis bugensis) are among the most ecologically and economically damaging invasive species in freshwater environments globally. While a range of control strategies has been developed, their effectiveness varies widely, environmental risks remain a

concern, and many approaches are costly or difficult to sustain over time. To synthesize the current state of knowledge, this scoping review followed Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines and analyzed 80 peer-reviewed studies published from 2000 onward. The review examined research trends, geographic patterns, and the relative effectiveness of different management approaches. Study activity clustered around two periods: 2009 to 2014 and 2018 to 2025, with the majority of research originating from the United States and Canada. Most studies focused on adult mussels in field or laboratory settings, and zebra mussels received more research attention than quagga mussels, though interest in the latter has grown over the past decade. Chemical control methods accounted for the vast majority of the literature, with copper-based molluscicides, chlorination, and ionic compounds being the most studied. Emerging options such as biopesticides and naturally derived compounds show promise but remain under investigated. Physical, mechanical, and biological approaches were examined far less frequently and are largely still in experimental stages. Across all methods, treatment success was influenced by mussel life stage, water temperature, chemical composition, and duration of exposure. This review identifies where chemical strategies have proven most effective, highlights critical research gaps, and calls for management solutions that are environmentally responsible, practically deployable, and integrative in nature, ultimately offering a foundation for evidence-based decision-making in invasive mussel control.

2.05.P-We043 Considerations for Selection of Bivalves for Marine Sediment Site Indigenous Human Health Risk Assessments

Ariel Blanc[1], Suzannah Schroeder[2], Sydney Gonsalves[2], Amy Corp[2], Michelle Havey[2], Mark Larsen[2], Nathan Soccorsy[2], Eric Crawford[3], Fiona Wong[4], Laurel Persowich[4], Kristin Ritchot[4], Robert Thomas[4] and Michael Bodman[5] (1)Anchor QEA LLC, (2)Anchor QEA, (3)Transport Canada, (4)Public Services and Procurement Canada, (5)Department of National Defence

Bivalves are commonly evaluated in marine human health risk assessments (HHRAs) focused on seafood consumption. As sessile species with limited metabolic capacity, they can provide site-specific information regarding potential accumulation of metals and organic contaminants from sediment and/or surface water into tissue. In the Salish Sea (British Columbia and Washington), bivalves can be consumed at relatively high rates by local indigenous communities and can be a major contributor to both seafood consumption risk and sediment remediation goal development. The bivalve data selected for use at a marine sediment site can have substantial implications on risk outcomes and drive selection of remedial goals.

Bivalve datasets collected for Salish Sea sites will be summarized. Based on this review, the following themes for consideration in selecting the bivalve data most appropriate to a given marine sediment site HHRA will be discussed: 1. In situ bivalve data indicate that clam tissue metals and organic contaminant concentrations are more strongly correlated with sediment concentrations, as compared to oyster and mussel tissue, and may be most relevant for use in HHRAs with the objective to understand the influence of sediment on seafood tissue concentrations; 2. The species of clams selected can impact risk outcomes and sediment remedial goal levels; and the use of Macoma sp. clams may bias high risk estimates and bias low sediment remedial goals. Though facultative deposit feeding Macaoma sp. are a common bioaccumulation test species, these species are not as commonly targeted for human consumption in the Salish Sea as other, obligate filter-feeding clam species. In situ biomonitoring data have indicated Macoma concentrations elevated up to 10 times for lead and copper compared to in situ filter-feeding clam concentrations, and bioaccumulation Macoma cPAH concentrations

have been observed up to 12 times higher than in situ filter-feeding clams exposed to similar sediment; 3. Depuration of filter-feeding clams may not be consistent with regional consumption patterns and may not notably impact tissue concentrations. In situ collocated depurated and non-depurated filter-feeding clam tissue concentrations were comparable for metals, cPAH, PCB, and dioxin/furans.

This presentation will show that these considerations can be informative, in combination with site-specific bioaccumulation information, for HHRAs in marine environments.

Evolving Science in the Canadian Oil Sands Region

2.06.T-01 Geology or Industry? Bitumen Erosion and Riverine Transport of Polycyclic Aromatic Compounds in the Athabasca River Basin

Colin Cooke[1], Alvin Kwan[2], Brandon Hill[2], Alberto Reyes[2] and Duane Froese[2] (1)Government of Alberta, (2)University of Alberta

Large-scale open-pit bitumen mining operations in Alberta, Canada have raised concerns about contaminant releases to downstream ecosystems and communities. Among the contaminants of concern are polycyclic aromatic compounds (PACs), a toxic group of organic pollutants prevalent at high concentrations in bitumen. Here I provide an overview of two recent studies aimed at quantifying and characterizing PACs in the Athabasca River, its tributaries, and in source materials. In tributary watersheds impacted by mining, PAC concentrations, loads, and yields all suggest the erosion of bituminous outcrops, rather than industrial inputs, is the main driver behind PAC input and riverine transport. In the Athabasca River itself, we quantified the concentration and composition of PACs in Big Bend, a ~4 km long and 18 m high cut bank rich in reworked bitumen-cemented unconsolidated sediments. Riverine erosion of Big Bend supplies ~410 kt of sediment and ~5.3 tons of PACs annually to the Athabasca River immediately upstream of the Peace-Athabasca Delta. Our results suggest Big Bend erosion supplies as much as half of the PACs transported by the Athabasca River.

2.06.T-02 Contaminant Exposure in Gulls and Terns Breeding Downstream of Athabasca Oil Sands Operations in Northern Alberta, Canada

John Chetelat[1], Craig Hebert[1], Christine McClelland[1], Maureen Angell[1], Colin A. Cooke[2], Jason Demers[3], Queenie Gray[4], Bruce Maclean[5], Lukas Mundy[1], Gregg T. Tomy[6] and Philippe J. Thomas[1] (1)Environment and Climate Change Canada, (2)Government of Alberta, (3)University of New Hampshire, (4)Parks Canada Agency, (5)Maclean Environmental Consulting, (6)University of Manitoba

Gull and tern eggs have been collected in receiving environments downstream of oil sands operations since 2009 to monitor contaminant burdens, inform on food safety and security, and investigate sources and pathways of contaminant exposure. Bird eggs are a useful indicator of wildlife exposure because females transfer contaminants to their eggs and the chemical composition of the eggs reflects their local environment during the breeding period. This presentation will provide a high-level overview of findings from long-term egg monitoring under the Oil Sands Monitoring Program and through collaborations between Environment and Climate Change Canada, Parks Canada and Fort Chipewyan community-based monitoring.

While the Peace-Athabasca Delta (PAD) is known to be an important receiving environment of the Athabasca River, egg monitoring has shown that much of western Lake Athabasca is also an important receiving environment and depositional area of the river. Evidence from isotopic tracers, specifically mercury stable isotopes and radiocarbon, shows the Athabasca River is a dominant pathway for mercury and carbon transport to the PAD and lake. Large inter-year differences of mercury in tern eggs from western Lake Athabasca are related to the flow of the Athabasca River, with a doubling of mercury concentrations in tern eggs following high flow years compared to low flow years. In some high flow years, egg mercury concentrations of Caspian Tern (Hydroprogne caspia) exceed a benchmark associated with greater risk of toxicological effects. Polycyclic aromatic compounds (PACs) in Caspian Tern eggs also show large inter-year differences in burdens, with above-background concentrations observed in most years. The PAC composition of Caspian Tern eggs (particularly the detection of alkylated dibenzothiophenes) is similar to that of bitumen, suggesting petrogenic origins of PACs in the eggs. In contrast, lower PAC burdens in eggs of two other bird species had chemical compositions consistent with pyrogenic or mixed sources. Together, these findings show high connectivity between contaminant loads in the Athabasca River and burdens in wildlife inhabiting downstream receiving environments. Source attribution remains a major challenge for monitoring contaminant exposure in wildlife, and new tools are needed to distinguish industry-released metals and PACs from other watershed sources.

Disclaimer/Disclosure: This work was funded under the Oil Sands Monitoring Program and is a contribution to the Program but does not necessarily reflect the position of the Program.

2.06.T-03 Exposure to Dibenzothiophene Disturbs Energy Production and Promotes Oxidative Stress in Human Placental Cells

Rodrigo Vargas[1], Vanessa Bautista[1], Lyla Bourque[1], Phillipe Thomas[2], Maria Lucia Bonfleur[3] and Alison Holloway[1] (1)Department of Gynecology and Obstetrics, McMaster University, Hamilton, ON, Canada, (2)Wildlife and Landscape Science Directorate, Environment and Climate Change Canada, Ottawa, ON, Canada, (3)Health Science Center, State University of Wester Parana, Cascavel, PR, Brazil

Introduction: The extraction and processing of bitumen in the Alberta oil sands is linked to the release of polycyclic aromatic compounds (PACs) in the environment. Some of these PACs have been shown to negatively impact pregnancy success and placental cell function. The heterocyclic PAC, dibenzothiophene (DBT), an organosulfur compound, has been measured in wildlife living near oil sands industrial activity. Work in our lab has demonstrated that DBT can impair placental cell function. Although the mechanisms underlying DBT-induced perturbations of placental cell function have not been fully elucidated, DBT has been shown to promote mitochondrial dysfunction in other tissues. Importantly, mitochondrial function is critical for normal placental function, as the placenta requires substantial energy production to sustain fetal growth and maintain gestational homeostasis. The goal of this study was to test the hypothesis that DBT perturbs energy metabolism in placental cells.
Methods: Human placental trophoblast cells (HTR-8/SVneo) were exposed to DBT (1 and 10 μM) for 48 hours. We assessed mitochondrial energy production (ATP), mitochondrial membrane potential (ΔΨm), mitochondria mass, oxidative stress (ROS, MDA) and OXPHOS protein expression.
Results: DBT exposure resulted in decreased ATP production, ΔΨm, mitochondria mass and downregulation of OXPHOS proteins in the electron transport chain. DBT also is associated with increased ROS and MDA levels as well as reduction of total antioxidant capacity (GSH). Moreover, DBT treatment resulted in a significant

increase in cellular iron content, promoting disturbance of enzymes with Fe-S cluster core.
Conclusion: Iron homeostasis in the placenta is recognized as critical for energy production, and the successful maintenance of pregnancy. Excessive intracellular iron disrupts the redox balance, which can result in cellular damage and ultimately lead to cell death. While this study provides evidence linking DBT to mitochondrial dysfunction and iron dysregulation in placental cells, further investigation is necessary to fully evaluate the impact of DBT exposure on pregnancy outcomes.

2.06.T-04 Using a Biomimetic Extraction-Solid-Phase Microextraction (BE-SPME) Test Method for Oil Sands Monitoring and Hazard Assessment

Barry Kelly[1], Alexander Cancelli[2], Asfaw Bekele[3], Jay Patel[2], Aaron Redman[2], Abraham Smith[2], Linso Varghese[2], Timothy Leshuk[4], Christoph Aeppli[5], Magdalena Rakowska[6], Yuki Gong[7], Kessmar Manahan[7], Heather Kaminsky[7], Lingling Yang[8], Mohamed Gamal El-Din[8], Samuel Pina Hodges[1] and Frank Gobas[1]
(1)Simon Fraser University, (2)Exxon Mobil, (3)No Affiliation, (4)H2nanO Inc., (5)Bigelow Laboratory for Ocean Sciences, (6)Envirostatus, LLC, (7)Northern Alberta Institute of Technology, (8)University of Alberta

Oil sands process-affected water (OSPW) is comprised of a complex mixture of organic and inorganic constituents generated during the bitumen extraction process used by the oil sands industry. A range of in situ treatment technologies are currently being developed and tested in Canada, with the intent of safe and responsible return of treated OSPW to the Athabasca watershed in northern Alberta. To support monitoring and hazard assessment of oil sands process water (OSPW), a biomimetic extraction via solid-phase microextraction (BE-SPME)-based analytical method has been developed to provide a surrogate measure of toxicity related to OSPW-derived bioavailable dissolved organic contaminants. Naphthenic acids (NA's) are the main class of organic compounds in OSPW. BE-SPME measurements have been shown to be highly correlated with Total NA concentrations, determined using orbitrap-high resolution mass spectrometry (HRMS).BE-SPME measurements have been used to characterize OSPW exposure and effects in aquatic organisms. This includes robust 14-28 day chronic exposure studies in early life-stage fathead minnow (Pimephales promelas) and rainbow trout (Oncorhynchus mykiss),, as well as 96 day chronic exposure tests in early life-stage amphibians, specifically wood frogs (Lithobates sylvaticus). These studies have demonstrated clear predictive BE-SPME concentration-response relationship. Currently, we are conducting several studies to strengthen and standardize the BE-SPME test method. This work includes (1) development of BE-SPME-based toxicity reference values (TRVs) for OSPW, based on species-sensitivity distributions (SSDs), which will aid provincial and federal regulatory agencies, tasked with developing water quality guidelines and hazard assessment; (2) modification and testing of the BE-SPME approach for assessing hazard of sediments and sediment pore-water; (3) a comprehensive inter-laboratory comparison studies involving standardization of laboratory protocols and practices and establishing quality assurance/quality control (QA/QC) and reporting requirements for the BE-SPME test method. Overall, the goal of this proposed work is to complete a series of laboratory-based investigations and data analyses to enable standardization of the BE-SPME test method, which aims to be a scientifically-defensible, cost-effective solution for rapid assessment of environmental quality and ecological hazard in Alberta's oil sands region.

2.06.T-05 Experimental Simulations of Oil Spills in Salmon-Bearing Rivers

Diane Orihel[1], Julie Adams[1], Mark Hanson[2], Peter Hodson[1], Bruce Hollebone[3], Chris Kennedy[4], Kevin

Mumford[1], Jason Raine[5] and Jules Blais[6] (1)Queen's University, (2)University of Manitoba, (3)Environment and Climate Change Canada, (4)Simon Fraser University, (5)University of Northern British Columbia, (6)University of Ottawa

We initiated the Pacific Salmon River Oil Experiment (ROE) Project to understand how spills of diluted bitumen into salmon-bearing rivers of British Columbia contaminate river sediments and affect early life stage salmon. Our hypothesis is that residual oil trapped in spawning areas serves as a chronic source of toxicity to developing salmon. This project focuses on oil behaviour, detection, effects, and remediation, and involves novel large-scale manipulations in outdoor river mesocosms. Our studies are primarily conducted at the Quesnel River Research Center in British Columbia's Cariboo region. The Quesnel River system supports five salmon species, including chinook salmon (Oncorhynchus tshawytscha), the study species of our research program. To begin, we conducted pilot studies to design experimental systems to simulate realistic water flows in salmon spawning habitats, develop husbandry techniques for monitoring salmon embryos in gravel beds, and test protocols for applying weathered oil to river gravel. In 2024, we conducted a comprehensive toxicological assessment of developing chinook salmon chronically exposed to a gradient of weathered diluted bitumen (1.7 to 67 g oil/kg gravel) in continuously flowing microcosm systems. In 2005, we conducted a full-scale oil spill study in ten large-scale (6 m long) experimental rivers (0.0032 to 3.2 g oil/kg gravel). In this presentation, we provide an overview of this multi-faceted research program and share three years of study results (2003-2005), including ecotoxicological data on survival, development, malformations, heart rate, respiration rate, and behavioral responses measured in bitumen-exposed fish, along with measurements of polycyclic aromatic compounds in water and fish tissues.

Disclaimer/Disclosure: Funding: NRCan, ECCC, NSERC.

Student Co-Authors: Rachael Brown, James Conway, Jeff Dodds, Marilyn Duncan, Matthew Gasparin, Anthony Iliou, Mikayla Melnick, Josie Rogers, Randeep Singh, Grace Thompson

Evolving Science in the Canadian Oil Sands Region

2.06.P-Th113 Microbes Endogenous to Oilsands-Eroding Tributaries Can Enhance Mobilization of Bitumen-Derived Naphthenic Acid Fraction Compounds Into Water

Ian J Vander Meulen[1], Dasiel Obregon-Alvarez[2], Andrew Conan[3], Chukwuemeka Ajaero[3], Dena W. McMartin[4], Robert B Brua[3], John V Headley[3] and Jordyn Broadbent[3] (1)University of Saskatchewan, (2)University of Guelph, (3)Environment and Climate Change Canada, (4)University of Lethbridge

The Athabasca Oil Sands Region (AOSR) has one of the world's largest petroleum reserves. Freshwater-intensive extraction of bitumen products has produced large volumes of oil sands process-affected water (OSPW) enriched in toxic naphthenic acid fraction compounds (NAFCs). While NAFCs have been proposed as potential forensic tracers of bitumen sources (i.e., naturally occurring vs processed ores), the mechanisms governing their mobilization from natural oilsands into aquatic systems remain poorly described. This study initially aimed to develop a forensic chemical fingerprint for natural bitumen weathering under the assumption that NAFC release would be dominated by physicochemical processes. However, laboratory equilibrations of oilsands with MilliQ as compared to AOSR tributary waters indicated that NAFC mobilization could not be

explained by physicochemical processes alone. These findings prompted a revised experimental design using liquid chromatography–Orbitrap mass spectrometry with amplicon-based microbial community sequencing to assess contaminant mobilization. Fresh oilsands from the Steepbank and Ells rivers were equilibrated with corresponding river waters under live and autoclaved conditions. Results demonstrated a strong and consistent influence of river microbial communities on NAFC concentrations, molecular characteristics, and temporal dynamics. Distinct differences in NAFC mobilization and speciation emerged rapidly between intact and sterilized systems, often within 30 min to 24 hrs, and persisted throughout incubation. While experiments demonstrate that variability associated with oilsand source, age, and solid matrix physicochemical characteristics influence absolute mobilization patterns, microbially mediated effects were evident across experiments. Investigation of microbial succession and ecological filtering revealed functionally coupled yet taxonomically distinct communities across systems, providing indication of region-specific consortia adapted to environmental petroleum pressures. Though a stable forensic fingerprint of "natural" oilsands weathering could not be established due to the multivariate nature of the study, this work demonstrates that biological drivers are critical determinants of NAFC release and attenuation. These findings emphasize the need to explore microbial processes in the context of contaminant fate assessment, natural attenuation potential, and risk determination for future OSPW releases in the AOSR.

2.06.P-Th114 Naphthenic Acid Fraction Components Impair Mammalian Placental Cell Function Through NRLP3 Pathway Activation

Rodrigo Vargas[1], Lyla Bourque[1], Vanessa Bautista[1], Richard Frank[2], Mark Hewitt[2], Phillipe Thomas[3] and Alison Holloway[1] (1)Department of Gynecology and Obstetrics, McMaster University, Hamilton, ON, Canada, (2)Water Science and Technology Directorate, Environment and Climate Change Canada, Burlington, ON, Canada, (3)Wildlife and Landscape Science Directorate, Environment and Climate Change Canada, Ottawa, ON, Canada

Introduction: Naphthenic acid fraction components (NAFC) are among the most abundant constituents of oil sands process-affected water (OSPW) and appear to be one of the primary drivers of reproductive toxicity through the induction of oxidative stress and mitochondrial dysfunction in aquatic species. However, the impacts of NAFCs on mammalian cell function are less well known. The mammalian placenta is critical for reproductive success. The initial placentation process is a dynamic balance between pro- and anti-inflammatory agents. There is increasing evidence demonstrating a link between oxidative stress, inflammation and placental dysfunction. The activation of NLRP3 axis play a role in pathophysiology of pregnancy loss and fetal growth restriction. This study aims to assess the effects of OSPW-derived NAFC on the NLRP3 inflammasome in placental trophoblast cells.

Methods: First-trimester human placental trophoblast cells (HTR8/SVneo) were exposed to NAFC isolate from OSPW at environmentally relevant concentrations [0.73, 1.5, 7.3, 14.7, and 58.6 mg/L] for 24 hours. We quantified ROS and ATP levels (a surrogate for mitochondrial dysfunction), as triggers for NLRP3 activation and the mRNA and protein expression of genes involved in the NLRP3 inflammasome (ASC, CASP1, NLRP3, IL1β, and IL18) pathway.

Results: NAFC exposure increased ROS and decreased ATP at the highest concentration tested. The NLRP3-related genes increased in a concentration-dependent manner (CASP1, ASC, NLRP3, and IL1β), with a

significant upregulation at the highest concentrations tested [14.7 and 58.6 mg/L].

Conclusion: Trophoblast cell health is important for proper placental development and function, and overall mammalian reproductive success. Findings from this study suggest that OSPW-derived NAFC caused increased ROS production and mitochondrial dysfunction, which in turn promoted activation of the NLRP3 inflammasome pathway. However, whether this results in increased production of pro-inflammatory cytokines or cell death remains to be determined.

2.06.P-Th115 Follow Their Nose: The Potential for Canine Detection of Oil Under Freshwater and Ice

Lauren Timlick[1], Paul Bunker[2], Vince Palace[1], Christina Brewster[2], James McCourt[3], David Dickens[4] and Ed Owens[5] (1)IISD Experimental Lakes Area, (2)Chiron K9, (3)SL Ross Environmental Research Ltd, (4)DF Dickens Associates LLC, (5)Owens Coastal Consultants

Effective oil spill response depends on rapid detection, yet submerged and under-ice spills remain difficult to locate using conventional sensors. Oil Detection Canines (ODCs) have proven reliable in shoreline surveys; to continue evaluating the limits of their capabilities, two field studies designed to challenge ODCs were conducted at the IISD-ELA in Northwestern Ontario.
In October 2024, a boat-based field trial investigated ODC detection of weathered oils submerged at depths of 1 to 5 m in a boreal freshwater lake. Using a double-blind design, an ODC team searched for triplicate targets of diluted bitumen (dilbit), Bunker C residual fuel oil, and Maya crude burn residue. The ODC successfully detected seven of eight dilbit targets and five of six Bunker C targets, while burn residue targets were not detected.
In January 2025, field trials assessed ODC detection of oil trapped beneath lake ice. Diesel fuel, a condensate blend, and Ultra-Low Sulphur Fuel Oil (ULSFO) were injected into ice capped cavities in a double-blind design. The ODC detected all six diesel and condensate/crude blend targets with no false positives across twelve blank holes. Detection was signalled at one of the ULSFO sites however, warmer weather during the ice cap refreeze caused some oil to resurface through the ice so this result was deemed an outlier.
Together, these studies demonstrate that ODCs can reliably detect a variety of submerged and under ice oil types across diverse conditions, offering real-time results, sensitivity to small deposits, and operational versatility that complements existing spill response tools.

2.06.P-Th116 Evaluating In Situ Biodegradation of Naphthenic Acids in a Constructed Wetland Treating Oil Sands Process-Affected Water

Jason M. E. Ahad[1], Aurélie Beaulieu-Laliberté[2], Paula C. J. Reis[3], Jérôme Comte[2], Douglas Muench[4] and Christine Martineau[1] (1)Natural Resources Canada, (2)INRS Eau Terre Environnement, (3)University of Waterloo, (4)University of Calgary

Treating oil sands process-affected water containing high levels of naphthenic acids (NAs) is an aspect of management for bitumen surface mining operations in Alberta's Athabasca oil sands region. Constructed wetland treatment systems (CWTSs) offer a potentially efficient and cost-effective approach to treating OSPW via microbial and plant-mediated attenuation of NAs. However, there is limited knowledge on how the ecology of microorganisms contribute to NA degradation under field conditions. Here, we deployed microcosms (i.e.,

'biotraps') containing carboxyl group 13C-labelled (99%) NA surrogates in a CWTS and applied stable isotope probing to detect and identify microorganisms involved in NA degradation under field-based conditions. Investigations were carried out using two different compounds commonly employed as NA surrogates: adamantanecarboxylic acid (ACA) and cyclohexanecarboxylic acid (CHCA). Phospholipid fatty acids (PLFAs) highly enriched in 13C were detected in microcosms incubated with CHCA as a substrate, confirming CHCA uptake by active microbial communities in the system under operating conditions. In contrast, however, no significant 13C-enrichment above natural abundance stable carbon isotope values (δ13C) was found in biotraps prepared using ACA. Using stable isotope probing, several bacterial 16S rRNA gene sequences affiliated to anaerobic taxa, notably sulfate- and iron-reducers, were identified in the heavy fractions after isopycnic DNA separation, suggesting that CHCA degradation occurred under anoxic conditions. The lack of noticeable 13C-enrichment in biotraps amended with ACA implies that more complex NA compounds may not be actively transformed by CWTS microbial communities.

2.06.P-Th117 Toxicity of Photooxidized Diluted Bitumen: Linking Photoproducts Formation to Molecular and Behavioral Responses to the Eastern Oyster (Crassostrea virginica)

Valentin Mettler[1], Ishfaq showket Mir[1], Jason Ahad[2] and Valerie Langlois[1] (1)National Institute for Scientific Research (INRS), (2)Natural Resources Canada

The expansion of Canadian crude oil extraction and export toward coastal regions, particularly through increasing pipeline infrastructure, underscores the need to better understand the environmental risks associated with accidental spills in marine ecosystems. There are increasing reports of how photooxidation of petroleum induces chemical changes corresponding to enhanced toxicity from photo-oxidized byproducts. Related characterizations of dilbit photooxidation in marine environments remains insufficiently characterized, particularly for diluted bitumen (dilbit) from the oil sands of Western Canada.

In this study, dilbit samples were experimentally photo-oxidized under simulated solar irradiation and chemically characterized using high-resolution Orbitrap mass spectrometry, with a focus on the formation and transformation of oxygenated polycyclic aromatic hydrocarbons (oxy-PAHs) and other photo-induced oxidation products such as naphthenic acid fraction compounds (NAFCs). Changes in chemical composition associated with sunlight exposure were investigated to better understand the production of potentially more bioavailable and toxic compounds. The ecotoxicological effects of this photo-modified dilbit were evaluated in the Eastern oyster (Crassostrea virginica), a filter-feeding sentinel species representative of North American coastal environments. Toxicity assessments combined molecular and behavioral endpoints through the analysis of gene expression related to stress and detoxification, as well as valvometry measurements to monitor alterations in breeding and feeding activity. We hypothesized a causal relationship between the increasing concentration of the oxidized species in the petroleum matrix and the toxicity of the mixture.

By coupling advanced chemical characterizations with biological response analyses, this work aims to improve our understanding of the links between dilbit photo-oxidation products, including oxy-PAHs and NAFCs, and their potential impacts on coastal aquatic organisms. This work is ongoing and contributes to improve risk assessment frameworks for oil spills in Canada's coastal environments by examining the impact of environmental degradation processes, particularly exposure to solar radiation, on the fate, transformation, and

toxicity of petroleum hydrocarbons.

2.06.P-Th118 Amphibian Indicators for Environmental Monitoring in Canada's Oil Sands Region

Lukas Mundy[1], Danna Schock[2], Maureen Angell[1], Julie Bilodeau[1], Doug Crump[1] and Bruce Pauli[1] (1)Environment and Climate Change Canada (ECCC), (2)Palustris Environmental

Herpetofauna have been historically underrepresented in ecotoxicological research and are often replaced by surrogate species in ecological risk assessments and environmental monitoring programs. This is despite evidence that amphibians and reptiles are sensitive indicators of ecosystem change. Their diverse life histories and documented global population declines further suggest their relevance in ecotoxicological research. As part of Environment and Climate Change Canada's (ECCC) contributions to a regional environmental monitoring program in northern Alberta (e.g. Canada-Alberta Oil Sands Monitoring Program), wildlife ecotoxicologists from ECCC have been tracking exposure to contaminants associated with bitumen resource extraction (e.g. metals, polycyclic aromatic compounds, naphthenic acids) in various wildlife receptor species, including amphibians, and using non-animal in vitro screening approaches for effects-based monitoring and hotspot identification. The use of wood frogs (Lithobates sylvaticus = Rana sylvatica) and other native amphibian species have a longstanding history, as sensitive indicators of wetland quality and aquatic contamination in Canada's Oil Sands Region. We present how ECCC has used, and continues to develop laboratory and field methods in a tiered testing framework to identify contamination hotspots and assess the risk of exposure to contaminant mixtures associated with oil and gas development to amphibians. We also explore the legislative landscape for environmental protection and conservation of herpetofauna in Canada and their importance and value to governments, regulators, and other stakeholders; especially when amphibians are included as indicators in environmental monitoring programs and ecological risk assessments.

2.06.P-Th119 Patterns of Naphthenic Acid Fraction Compound Occurrence Among Oil Sands-Affected Wetlands: A Regional Chronosequence Survey

Ian Vander Meulen[1], Jan J.H. Ciborowski[2], Camryn Charriere[2], Dena McMartin[3], Markus Brinkmann[1], Douglas Muench[2] and John Headley[4] (1)University of Saskatchewan, (2)University of Calgary, (3)University of Lethbridge, (4)Environment and Climate Change Canada

Natural and opportunistically-forming wetlands are common in oilsands landscapes reclaimed following open-pit mining. Naphthenic acid fraction compounds (NAFCs) are one of the primary contaminant classes associated with oilsands mining, raising concerns about where NAFCs may occur and persist over time in surface waters. Because reclaimed landscape succession occurs over decades, regular sampling programs cannot feasibly capture this long-term trajectory. This study instead analyzed a chronosequence of samples from ~110 wetlands within or near oil sands mine lease areas to infer age-associated NAFC concentrations and characteristics. Wetland water samples were analyzed by high-resolution Orbitrap mass spectrometry and compared by multivariate ordination approaches. Bitumen-associated spatial gradients were apparent in the NAFC-derived data, exceeding the importance of covariate wetland parameters such as size, permanence, age, or specific site histories. Northern Alberta reference wetlands were deplete in NAFCs (< 2 mg/L) and were dominated by complex DOM and ubiquitous fatty acids. The youngest wetlands (~<10 y since formation) influenced by bitumen-derived materials had less-complex spectra than older wetlands with analogous input

histories. Recently-formed wetlands (including those in landscapes undergoing active reclamation; 3-16 y since formation) had the greatest overall NAFC content (50 – 150 mg/L), the greatest proportion of naphthenic acids (i.e., O2-NAFCs), and the lowest overall diversity of identified formulae. Slightly older wetlands fell into two distinct sub-groups. Wetlands subject to ongoing bitumen-derived influences (e.g., bitumen within the drainage catchment) had lower concentrations than their younger counterparts, but nonetheless had elevated NAFC concentrations (8 – 50 mg/L) and lesser congener diversity relative to wetlands in reference landscapes. Some industrially-affected wetlands of similar age (i.e., 3-16 y) were often similar to regional reference sites in the absence of ongoing stressors (i.e., bitumen-derived inputs), suggesting that NAFCs attenuated in these young ecosystems in the absence of ongoing inputs, corroborating regional wetland resilience to bitumen-derived contaminants. While these data do not directly inform risk assessments, these results suggest that effective sequestration of bitumen-affected materials in closure landscapes will likely limit legacy impacts of related contaminants.

Disclaimer/Disclosure: Work supported by an NSERC-COSIA Industrial Research Chair (Jan Ciborowski) and funding from Natural Resources Canada's Office of Energy Research and Development (John Headley)

2.06.P-Th120 Multi-Trophic Assessment of Oil Sand-Derived Naphthenic Acid Fraction Component Toxicity

Richard Frank[1], Adrienne Bartlett[1], Jordyn Broadbent[1], Mark Hewitt[1], Patricia Gillis[1], Joanne Parrott[2], Martina Rudy[2], Erin Ussery[1] and Robert Brua[2] (1)Environment and Climate Change Canada (ECCC), (2)Environment and Climate Change Canada

The oil sands region in northeastern Alberta, Canada is one of the largest proven oil reserves in the world. Development of the surface mining portion of the oil sands reserve continues to expand, resulting in increasing volumes of oil sands process-affected water (OSPW) produced during bitumen extraction processes. One of the known principal toxicity drivers in OSPW is a mixture of soluble organics often referred to as Naphthenic Acid Fraction Components (NAFCs) that includes classical naphthenic acids ($C_nH_{2n+z}O_2$) and similar compounds (e.g., aromatic, alkyl substituted, etc.). Due to the reported toxicity of NAFCs and the focus on them in remediation and monitoring initiatives, there is a committed effort to establish water quality objectives for this complex mixture. Using a suite of bioassays employing multiple taxa and acute and sub-lethal endpoints, an extracted mixture of NAFCs isolated from OSPW and a commercial mixture of classical naphthenic acids (NAs; isolated from traditional petroleum sources) were investigated. Across all species tested, the commercial NA mixture exhibited a greater acute toxicity than the isolated NAFCs (when an effect concentration could be derived), however in sub-lethal tests the derived effect concentrations were often much closer in value (e.g., Daphnia magna reproduction) or even more toxic for the NAFCs (e.g. Green algae strains Raphidocelis subcapitata and Anabaena flos aquae). Quantitative and qualitative analytical characterization is currently underway for the various test solutions with the objective to further elucidate the toxicity drivers in these highly complex mixtures, and the resulting derived toxicity values will inform discussions on the establishment of water quality objectives.

2.06.P-Th121 Environmental Hazard Assessment of Metal Salts of Naphthenic Acids

Rhiannon Smith[1] and Oliver Tosic[2] (1)wca environment Ltd., (2)Rhenus Lub GmbH & Co KG

Many regulatory assessment criteria are not directly applicable to UVCBs (substances of unknown, variable or complex composition or of biological origin). This presentation provides examples of the approaches considered and the challenges encountered for the biodegradation and aquatic ecotoxicity assessment of a metal salt of naphthenic acids containing more than 100 constituents.
Ready biodegradation testing was conducted on the substance itself, using an adapted OECD 301 method extended to 60 days and using a solid inert carrier due to the sticky nature of the test item. It was not feasible to test at a concentration below the NOEC for the metal ion, so the test was repeated at different concentrations. However, ready biodegradability tests are generally not applicable for UVCBs, as degradation may represent removal of only some constituents. Therefore, other data sources were considered. No data were identified for most representative structures and isolation of specific constituents is not feasible. Data were read across from naphthenic acids, but reading across from organic components to metal salts may not reflect potential differences in solubility. QSARs predictions were modelled for representative structures for the organic components (as metal salts are outside the domain of many models), either as individual constituents where they were identified, or representatives for groups of constituents based on carbon number and hydrocarbon class (hydrocarbon blocks) identified from the analysis of the test item. The data were combined into a weight of evidence approach, but this is difficult to assess directly against ready biodegradability criteria.
Short-term aquatic toxicity tests on the salt were conducted as water accommodated fractions and reported as nominal loading rates. Metal and TOC were measured but specific organic or salt analysis was not feasible due to the large number and low concentrations of constituents. The presence of the metal is likely to contribute to toxicity so a transformation/dissolution test was conducted to measure the available metal concentration.
A number of approaches have been applied for the metal salt considering the whole substance, both the organic and inorganic components and addressing its complex UVCB nature. This case study provides an example of potential approaches for fate and ecotoxicity assessment substances which are complex and difficult to characterise, test and analyse.

Fate and Effects of Contaminants and Complex Mixtures in the Marine Environment

2.07.T-01 Development and Application of a Standardized Test With a New Marine Algae in Canadian Effluent Regulations

Carolyn Martinko[1], Paige Cochrane[2], Melanie Gallant[3], Cintia Glasner Regis[2], Sarah Costantini[2], Lisa Taylor[2] and Leana Van der Vliet[1] (1)Environment and Climate Change Canada (ECCC), (2)Nautilus Environmental Company Inc., (3)Nautilus Environmental Company

The Pulp and Paper Effluent Regulations and the Metal and Diamond Mining Effluent Regulations pursuant to the Fisheries Act require sublethal toxicity testing on effluent discharged into marine or estuarine environments using marine algae species. Historically, reproduction tests using Champia parvula were used, but this test is no longer offered by North American labs due to concerns regarding data reproducibility and lack of available new organisms. Issues with toxicity tests using giant kelp (Macrocystis pyrifera) also became apparent over time, as the need for field collection of giant kelp, transport across the US-Canada border, and narrow ranges for life stage and effluent holding times contributed to growing logistical obstacles. To address this regulatory gap,

Environment and Climate Change Canada (ECCC) in collaboration with Nautilus Environmental refined an existing standardized test (ISO 10710:2010) with the marine algae Ceramium tenuicorne, and confirmed successful implementation in a Canadian laboratory. Method verification was conducted over 3 years, which included culturing, reference toxicant testing, and effluent testing on >20 samples from various industrial facilities. Knowledge gained from laboratory application was reflected in the additional guidance developed by ECCC, including method refinements to improve ease of implementation. Selected results from laboratory work and regulatory adoption will be discussed in this presentation, including ecological rationale, evaluation of quality assurance and quality control data, and steps taken to customize the test method for adoption into Canadian effluent regulations.

The final Canadian standardized test method, termed "add-on" to reflect the need to use the ISO 10710:2010 standard as a foundation, was published in April 2025. It is freely available at https://www.canada.ca/en/environment-climate-change/services/wildlife-research-landscape-science/biological-test-method-publications.html At the time of writing, the culture was in the final stages of accessioning to the Canadian Phycological Culture Collection (CPCC) at the University of Waterloo.

2.07.T-02 Responses of Marine Mussels (Mytilus spp.) to Contaminant Mixtures Adsorbed Onto Polystyrene

Mathilde LÊ[1], Clément Baratange[1], Jocelyn Sutedja[1], Cassandre Jeannot[2], Gaud Dervilly[2], Marie-Hélène Ropers[3], Bruno Cognie[1], Paul Deleris[4], Laurence Poirier[1] and Aurore Zalouk-Vergnoux[1] (1)University of Nantes, (2)Laberca, (3)INRAE, (4)No Affiliation

In aquatic environments, organic and inorganic contaminants can sorb onto microplastic surfaces, potentially increasing their bioavailability and transfer to living organisms. As sedentary filter-feeders, mussels are particularly exposed to this combined contamination, making them relevant sentinels for assessing effects across all biological levels.
This study investigated the effects of polystyrene microspheres (PSm, 38-48 µm) sorbing a cocktail of organic and inorganic contaminants representative of marine coastal environments on Mytilus spp. The cocktail included 1 PAHs, 4 pesticides, 2 PFAS, and 2 PCBs, as well as three trace metals (Cd, Pb, and As), all at environmentally realistic concentrations.
About the exposure, 4 conditions were tested: (1) control, (2) cocktail without PSm (3) PSm without cocktail, and (4) PSm sorbing the cocktail. The PSm sorbing the cocktail were prepared by: dissolution of organic contaminants in solvent, addition of PSm, solvent evaporation under a fume hood, immersion in metal-contaminated seawater for 48h (agitation, dark, 15°C), before being filtered. Ninety mussels per condition were distributed in 5 tanks, acclimated during one week and exposed for 8 days in artificial seawater (33 PSU, 15°C, 12h/12h circadian cycle, 1 mussel/L), fed daily with Tisochrysis lutea.
Biological responses were assessed at multiple levels and in 3 different organs (digestive gland, gills, mantle), by the measure of clearance rate, biochemical biomarkers of oxidative stress and neurotoxicity as well as untargeted transcriptomic and lipidomic approaches.
Only As and Benzo(a)pyrene were detected and quantified after applying the sorption protocol of contaminants onto PSm, extraction and analysis. The clearance rate of mussels exposed to the cocktail was significantly higher than the clearance rate of control mussels (Anova test, $p=0.016$), while PSm with or without cocktail did not lead to significant effect. Oxydative stress was highlighted with the analysis of lipid hydroperoxides

(LOOH) in gills, which revealed a significant effect of PSm without cocktail compared to control (Anova test, p=0.045).
The results of this study helped to fill the gap of determining if microplastics can be considered as a source or a sink of contaminants under realistic conditions, thereby contributing to the assessment of environmental risks associated with exposures combining different chemical stressors in marine ecosystems.

2.07.T-03 Whole-Body Assessment Reveals New Insights Into Overall PFAS Burden in Marine Predators: The Bonnethead Shark and Atlantic Stingray

John Bowden[1], Qaim Mehdi[2], Gareth Fraser[1] and Douglas Adams[3] (1)University of Florida, (2)Yale University, (3)Florida Fish and Wildlife Conservation Commission

In marine ecosystems, PFAS biomagnify in predators, which may lead to significant health risks and a disruption of long-term ecosystem stability. Body burden studies are an important and unique strategy for providing insight into the overall quantity of select chemicals within an organism, and subsequently, their whole-body distribution. In this study, we examined the whole-body distribution of PFAS in two benthic marine predators along the coastline of Florida, the bonnethead shark (n=6, 3 adult male and female, Sphyrna tiburo) and the Atlantic stingray (n=6, 3 adult M and F, Hypanus sabinus). In addition to the association of elevated PFAS levels with benthic behaviors, both species are also bioturbators, which likely augments exposure. Following necropsy, all unique tissues and organs (tissues per animal: n = 18 for shark, n = 14 for rays) from each elasmobranch were carefully dissected, weighed, and extracted prior to a targeted quantitative analysis of PFAS carried out using a Thermo Scientific Vanquish ultra-high pressure liquid chromatography coupled to a Quantis triple quadrupole mass spectrometer. In this study, we investigated the tissue-specific distribution and whole-body burden of PFAS in bonnetheads sharks and stingrays. A total of 11 of 25 target PFAS were widely found in different tissues of bonnetheads analyzed, while 11 of 66 PFAS tested were quantified in the stingray tissues. Among the tissues tested, included blood, brain (and dissected into compartments for the sharks), brain fluid, eggs (sharks), eyes, fins and tail, gills, heart, intestine, kidney, liver, muscle, nasal capsules (shark), pancreas, rectal gland, skin, spleen, stomach (and contents), testes, uterus, and other remains. Heat maps illustrate the variability within each tissue and across tissues (both by concentration but also by total quantity of each PFAS). Among the detected PFAS, PFOS was measured at the highest concentrations across tissues. To the best of our knowledge, this study is the first to report tissue-specific distribution and whole-body burden of PFAS in elasmobranchs, which fills a knowledge gap in PFAS-related marine biology.

2.07.T-04 From Water to Blue Crabs: Tracing PFAS Through Maryland Estuarine Ecosystems

Michella Salvitti[1], Eguono Omagamre[1], Joseph Pitula[1] and John Bowden[2] (1)University of Maryland Eastern Shore, (2)University of Florida

Per- and polyfluoroalkyl substances (PFAS) are persistent contaminants that are increasingly detected in estuarine ecosystems and may affect immune function and other physiological processes in aquatic organisms. However, little is known about how PFAS exposure may influence host-pathogen interactions in ecologically and economically important species. The Atlantic blue crab (Callinectes sapidus) supports valuable fisheries throughout the Atlantic and Gulf coasts of the United States and is susceptible to infection by the parasitic dinoflagellate Hematodinium perezi.

To assess PFAS occurrence and potential ecological implications, blue crabs and surface waters were sampled throughout the Chesapeake Bay and Maryland Coastal Bays. PFAS were detected in 70% of water samples, with median ΣPFAS concentrations of 7.80 ± 1.30 ng/L. PFAS were also detected in 70% of blue crab hepatopancreas and claw tissue samples, with ΣPFAS concentrations ranging from 0.79 to 5.49 ng/g, demonstrating widespread exposure and bioaccumulation within estuarine food webs.

Building on these findings, a separate investigation examined relationships between PFAS exposure and H. perezi infection. Hemolymph samples collected from blue crabs in the Maryland Coastal Bays were analyzed for PFAS and screened for H. perezi using quantitative PCR. Four PFAS compounds were detected in hemolymph, with perfluorobutane sulfonic acid (PFBS) representing the dominant contributor to total PFAS burden. Crabs testing positive for H. perezi exhibited approximately four-fold higher average ΣPFAS concentrations than uninfected crabs (24.9 ng/g versus 6.2 ng/g). Elevated PFBS concentrations were particularly associated with infected individuals.

These findings suggest that PFAS exposure may influence disease dynamics in estuarine ecosystems by affecting host susceptibility to parasitic infection. As PFAS continue to persist in coastal environments, understanding how contaminant exposure interacts with infectious disease will be critical for predicting impacts on blue crab health, population resilience, and the broader ecological functioning of coastal ecosystems.

2.07.T-05 From Sources to Sinks: Ecosystem-Scale Drivers of Microplastic Accumulation and Exposure in the Galápagos

Ceri Lewis[1], Georgie Savage[1], Jen Jones[2], Gustavo Dominguez[3] and Tamara Galloway[1] (1)University of Exeter, (2)Galapagos Conservation Trust, (3)Higher Polytechnic School of the Coast (ESPOL)

Despite strong environmental protections, significant levels of plastic and microplastic pollution are accumulating in the Galápagos Archipelago. The islands' unique geography and conservation status provide a natural laboratory to investigate the mechanisms governing the sources, transport, transformation, and ecological exposure of plastics at an ecosystem scale. Here we present findings from a five-year collaborative research programme (2018–2023) examining the sources, fate, and behaviour of microplastics across the Galápagos marine system, alongside their uptake into endemic biota and implications for mitigation and management strategies. Samples were collected from seawater, benthic sediments, beaches, mangroves, and invertebrate fauna at multiple sites around the island of San Crisobal, complemented by macroplastic surveys.

Microplastic contamination was widespread but exhibited strong spatial structuring linked to both oceanographic and anthropogenic drivers. In particular, microplastic particle type showed clear spatial patterns likely related to source. Plastic fragments dominated eastern sites influenced by the Humboldt Current suggesting mainland sources, while fibres were more prevalent in western regions, reflecting local inputs from fisheries and local wastewater inputs. Elevated microplastic concentrations in harbour waters, particularly near outfall infrastructure where concentrations of 19.7 +/- 1.9 MP L-1 were recorded, further support a significant contribution from land-based sources, with anthropogenic cellulose fibres suggesting urban wastewater as a key pathway. Mangrove ecosystems emerged as critical retention and accumulation zones within the archipelago, with microplastic concentrations in mangrove waters reaching up to four orders of magnitude higher than adjacent open waters. Mangrove sediments contained 102.05–196.95 particles g^{-1}, among the highest recorded

globally for mangroves. These systems appear to act as effective sinks, modulating the distribution and residence time of microplastics and creating localised hotspots of exposure.

Together, these findings highlight how interactions between ocean currents, local human activities, and habitat complexity drive the formation of microplastic accumulation hotspots and influence exposure pathways for marine organisms. This mechanistic understanding is now informing targeted management interventions and mitigation strategies within the Galápagos National Park.

Disclaimer/Disclosure: This study falls under the "Understanding the Effects of Marine Debris in the Galápagos" permit authorised by the Galápagos National Park Directorate and the Galapagos Science Center (GSC) (PC-44-18 and PC-23-19). This research was funded by the UKRI Global Challenges Research Fund (NE/V005448/1).

2.07.T-06 Updated Meta-Analysis: Data Quality Evaluation of Microplastic Toxicity Studies on Marine Invertebrates and Effects of Particle Dimensions

Shuo Yu[1], Kyle Fetters[1], Allie Gobeil[1], Sydney Kruse[1] and Phyllis Fuchsman[1] (1)Ramboll

In the evolving science of microplastics ecotoxicology, the lack of a standardized testing protocol represents a major research gap, complicating direct comparisons of toxicity studies conducted with microplastics that differ in polymer type and particle dimensions (e.g., particle size and shape). Building upon our initial work in 2024, this updated meta-analysis has two objectives: 1) to systematically assess the data quality of microplastic toxicity studies with marine crustacean and mollusk species published in the literature, and 2) to evaluate the effects of particle size, shape, and polymer type of microplastics on the organism- and population-level subchronic/chronic toxicity endpoints. We expand our 2024 data set by compiling results from controlled toxicity experiments on target species and endpoints published in the most recent literature that report the polymer type and particle dimension parameters, with a particular focus on review papers. Each study is evaluated against twenty quality criteria in the context of ecological risk assessment, and a reliability score is assigned. Where data quality and availability permit, dose-response analyses are performed to compare the impacts of polymer type and particle dimension parameters on dose-response relationships and derivation of effect concentrations. A quantitative and/or qualitative discussion of ecological impacts associated with weathered versus non-weathered microplastic particles is also included. The meta-analysis concludes by identifying research gaps revealed by the data-quality assessment and dose-response evaluation and by offering recommendations for standardizing microplastic toxicity testing protocols, aiming to improve comparability across studies, strengthen understanding of microplastic toxicity, and inform future ecological risk assessments and regulatory decision-making.

Fate and Effects of Contaminants and Complex Mixtures in the Marine Environment

2.07.P-We044 Combined Effects of Temperature and per- and Polyfluoroalkyl Substances (PFAS) Exposure on the Marine Copepod Tigriopus japonicus

Carter Eagles[1] and Jordan Park[1] (1)Université Sainte-Anne

Anthropogenic environmental stressors, including chemical pollution and climate change, increasingly threaten aquatic ecosystems by disrupting physiological processes that underpin organismal fitness and population stability. Per- and polyfluoroalkyl substances (PFAS) are a class of persistent contaminants that have become globally distributed throughout marine and freshwater environments due to their widespread industrial and commercial use. Concurrently, rising global temperatures may alter the toxicity of environmental contaminants, highlighting the need to assess the combined impacts of chemical and climate-related stressors on aquatic organisms.

To investigate the combined effects of per- and polyfluoroalkyl substances (PFAS) and elevated temperature on marine organisms, the harpacticoid copepod Tigriopus japonicus was exposed to four PFAS compounds: the long-chain PFAS perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS), and the short-chain alternatives perfluorohexanoic acid (PFHxA) and perfluorohexane sulfonate (PFHxS), hence enabling us to compare toxicity based on carbon-chain length and functional group chemistry (carboxylates versus sulfonates). Organismal responses were evaluated through in-vivo endpoints including survival, development, and reproductive performance, while in-vitro assays including oxidative stress was assessed by measuring reactive oxygen species (ROS) production and the activities of antioxidant enzymes, including glutathione S-transferase (GST), superoxide dismutase (SOD), and catalase (CAT). To further elucidate mechanisms of toxicity, global transcriptomic analyses were conducted to identify differential gene expression patterns and affected molecular pathways. By integrating organismal, biochemical, and transcriptomic endpoints, this study provides a comprehensive assessment of PFAS toxicity under warming conditions and improves our understanding of how climate change may alter contaminant impacts in marine ecosystems.

2.07.P-We045 Implementation of a CO2 Evolution Test Design in Seawater Using Natural and Synthetic Polymers

Roxanne Brackett[1], Julia Mason[1] and Sean McLaughlin[2] (1)Smithers LLC, (2)Smithers

According to some estimates, at least 8 million metric tons of plastic enter our oceans each year and that is on top of the 200 million metric tons of plastic already circulating in our oceans (Oceans Conservancy.org). At the same time the assessment of persistence of polymers and other organic chemicals is increasingly scrutinized especially in marine environments.
Environmental agencies have required the conduct of standardized tests to assess chemical persistence now for decades. Several of these standardized tests assess persistence or their potential to ultimately biodegrade by following the amount of CO2 produced after the chemical under study is in contact with an inoculated matrix. Most of the CO2 evolution methods are used with dilute inoculums, which generate low levels of endogenous CO2 which is useful in the experiment to reduce matrix effects that could otherwise mask biodegradation results. Such methods are especially useful when working with low water soluble and/or adsorptive chemicals. However, such CO2 evolution techniques are generally not part of the standard suite of tests used in the OECD

guidelines for testing in seawater, although there is a procedure in the ISO guidelines. Difficulties with current seawater procedures have often been related to high background matrix effects, which impact endogenous DOC concentrations, deplete O2 content, and increase CO2 amounts.
In this presentation, we will discuss techniques that remove matrix effects but still represent the natural ocean microflora while using multiple CO2 evolution test designs to assess the ultimate biodegradation of polymers in seawater. At least three natural polymers representing a disaccharide, protein, and fat have been used to show proof-of-concept of these procedures, and results will be presented and compared to a typical reference compound along with a more challenging polymer found in the oceans today.

2.07.P-We046 Exploring the Safety of Seawater Alkalinity-Enhancement on Commercially and Ecological Important Species for Atlantic Canada

Davide Asnicar[1] (1)Huntsman Marine Science Centre

Growing interest in limiting global warming and climate change effects is leading academic and industrial scientists' efforts to explore actionable solutions, such as decarbonization and carbon dioxide (CO_2) removal. Marine carbon dioxide removal (mCDR) includes ocean-based processes designed to remove CO_2 from the atmosphere and/or biomass plants, and convert it to bicarbonate that is then stored in the ocean. One promising mCDR technique is accelerated weathering of limestone (AWL), which consists of mixing seawater, calcium carbonate, and a CO2-rich waste gas to increase seawater alkalinity, mimicking natural processes. This process captures CO2 and converts it into bicarbonate in an engineered system before the discharge waters are released, making it easy to measure and monitor, instead of waiting on the CO2 to dissolve through air-sea gas exchange as required by other methods. To implement these technologies safely, key biological and environmental questions need to be addressed.
In this project, the potential ecotoxicological impacts of AWL-like alkalinity-enhanced seawater will be assessed on various marine species important for Atlantic Canada and beyond, covering different trophic levels, and environmental compartments. Acute and chronic tests will be performed to determine safety thresholds for two microalgal species, green sea urchins, American lobster larvae and post-larvae, the copepod Acartia tonsa, and blue mussels. Multiple species-specific metrics will be evaluated throughout the study to identify biological changes attributable to exposure to alkalinity-enhanced waters.
Insight from this first attempt at determining safety thresholds for alkalinity-enhanced seawater will be invaluable for future, large scale deployment of this technology.

2.07.P-We047 Multi-Matrix Assessment of PFAS Contamination in a Highly Urbanized New Jersey Estuary

Thivanka Ariyarathna[1], Daniel Jasinski[1], Daehan Bong[1], Sara Nason[2], Priyankar Chand[2], Gustavo Garcia[2], Jasmine Jones[2] and Mark Sullivan[3] (1)Rowan University, (2)Connecticut Agriculture Experiment Station, (3)Stockton University

Per- and polyfluoroalkyl substances (PFAS) are persistent environmental contaminants of emerging concern with incompletely characterized health impacts and exposure pathways. PFAS enter the environment through both point and non-point sources, yet comprehensive data on PFAS contamination in southern New Jersey's coastal and estuarine environments remain limited. Absecon Bay is a coastal water body near Atlantic City that receives freshwater from Absecon Creek and stormwater via urban drainage pathways such as the Absecon

Channel, which may transport PFAS and other urban contaminants into the bay. This study aimed to determine PFAS contamination in surface water, groundwater, sediment, and biota around Absecon Bay. Samples were collected during summer 2025 from sites inland within the bay and near the inlet connected to the open ocean, representing areas with distinct environmental characteristics. Biota samples encompassed four trophic levels from benthic and pelagic food webs, while water quality parameters and sediment characteristics were measured at each sampling location. Samples were processed and analyzed using ultra-performance liquid chromatography-mass spectrometry to quantify 19 PFAS compounds, including long- and short-chain perfluoroalkyl carboxylic acids and perfluoroalkyl sulfonic acids, encompassing legacy and emerging PFAS, using an adapted version of US-EPA Method 1633. PFAS concentrations in surface water, groundwater, sediment, plankton, finfish and shellfish will be investigated to characterize PFAS contamination and sources in Absecon Bay. Bioaccumulation of PFAS in coastal species will be comprehensively assessed providing important information on public health and ecological risks. PFAS occurrence and profiles in water and sediment will provide critical insight into contamination severity, source management, and environmental risk assessments for southern New Jersey coastal communities.

2.07.P-We048 Assessing the Sources and Distribution of Wastewater-Derived Contaminants in the Strait of Georgia Using Caffeine as a Tracer

Jeffrey Wight[1], Richard Pawlowicz[2] and Rachel Scholes[2] (1)University of British Columbia (UBC), (2)University of British Columbia

The Strait of Georgia (SoG) is an inland sea situated between Vancouver Island and the mainland of British Columbia, Canada. Like many coastal areas, the SoG is home to fragile ecosystems while also serving as a receiving body for the wastewater of the communities along its shores, most notably Vancouver. The wastewater treatment plant (WWTP) at Iona Island, which handles nearly half of the wastewater generated by the Vancouver Metropolitan Area, is one of the last major primary treatment plant facilities on the west coast of North America and discharges directly into the SoG. Additionally, the SoG receives water from the Fraser River which carries discharge from three secondary WWTPs and untreated effluent from combined sewer overflows (CSOs). Despite large inputs of wastewater into the SoG, high dilution means that some contaminants may be present at concentrations below detection limits while still being toxicologically relevant. Therefore, we used caffeine as a tracer to evaluate the distribution of wastewater contaminants in the SoG. Our study consisted of three phases: semi-regular monitoring of SoG locations near Vancouver, a two-week survey of the SoG and its connected waterbodies where over 123 samples were collected, and characterization of known sources of wastewater (treated wastewater effluent from a primary and secondary treatment plant, CSOs, and the Fraser River). Results from the source characterization were used as inputs to a box model of the SoG and modeled concentrations were compared to observations in environmental samples to assess the relative contributions of each source. We found that caffeine concentrations were highest near the Iona Island Outfall, but caffeine was present in every sample from the SoG and the neighboring waterbodies, with concentrations ranging from 1.65 to 156.6 ng/L. The Iona Island WWTP was found to be the largest single source of caffeine to the SoG, while secondary treatment plants and CSOs contributed far less. Initial comparisons of field data with the box model suggest that wastewater from Vancouver is responsible for a significant portion of contamination, but other significant sources may exist. The results of this study aim to quantify wastewater pollution in the SoG, support efforts to improve wastewater infrastructure, and increase public support for protections for marine and estuarine environments.

2.07.P-We049 Photooxidation-Driven Fate of Diluted Bitumen in Aquatic Environments: Formation of Oxy-PAHs and Other Photoproducts

Ishfaq showket Mir[1], Valentin Mettler[2], Jason Ahad[3], Md Samrat Alam[3] and Valerie Langlois[2] (1)Institut National de la Recherche Scientifique, (2)National Institute for Scientific Research (INRS), (3)Natural Resources Canada

Diluted bitumen (Dilbit) released into aquatic environments is expected to undergo extensive photochemical aging under ultraviolet irradiation, leading to oxidation of its molecular constituents and the formation of more polar transformation products. These processes are anticipated to alter the distribution, composition, and environmental behavior of petroleum-derived compounds, particularly oxygenated polycyclic aromatic hydrocarbons (oxy-PAHs) and related oxygenated species. UV-driven transformations are expected to proceed through radical-mediated pathways involving aromatic functionalization, side-chain oxidation, and progressive incorporation of oxygen into the petroleum matrix. In this study, dilbit was exposed to controlled UV irradiation using a solar lamp system to simulate photochemical weathering under defined conditions. High-resolution GC-Orbitrap mass spectrometry was used to characterize changes in molecular composition before and after irradiation, with emphasis on the emergence of oxygen-rich photoproducts. The analytical approach was designed to resolve shifts in heteroatom-containing species, oxidation state, and molecular diversity associated with photooxidative processing. These measurements are expected to provide a detailed chemical framework for evaluating the susceptibility of dilbit to photochemical transformation. This work aims to improve the understanding of dilbit photooxidation and the role of light-driven reactions in governing the post-release chemistry of complex petroleum mixtures. The study will contribute to a more predictive understanding of how photochemical weathering influences the molecular evolution and environmental persistence of diluted bitumen.

2.07.P-We050 Uptake of Sediment-Associated Hydrocarbons by English Sole (Parophrys vetulus) in Coastal British Columbia, Canada

Emily O[1], Peter S. Ross[2] and Tanya M. Brown[1] (1)Simon Fraser University, (2)Raincoast Conservation Foundation

Polycyclic aromatic hydrocarbons (PAHs) are toxic, widespread contaminants with coastal hotspots in British Columbia (BC) sediments that pose risks to aquatic biota. PAHs are introduced into marine ecosystems from various sources, including combustion, urban runoff, spills and natural sources. The completion of the Trans Mountain Pipeline Expansion has raised concerns about operational and accidental releases by oil tankers, with a seven-fold increase in tanker traffic over the past two years. Despite this, the extent of current PAH exposure and the transfer of sediment-associated PAHs to biota remains poorly understood. Benthic species such as English sole (Parophrys vetulus) are especially vulnerable to PAH uptake and have been used to monitor sediment-associated contaminants and effects. We investigated PAH concentrations and profiles in whole body English sole (n=40) and paired sediment samples (n=16) collected at reference (Hecate Strait), semi-urban (Howe Sound), and urban (Vancouver Harbour) sites. Samples were analyzed using gas chromatography-mass spectrometry for 76 PAH analytes. PAH concentrations increased in near-urban areas, with the highest concentrations in Vancouver Harbour for both English sole and sediment. Many sediment samples had PAH concentrations that exceeded Canadian Sediment Quality Guidelines. Diagnostic ratios using 4-ringed PAHs were similar in English sole and sediment, suggesting sediment as an exposure pathway for this benthic fish and highlighting fish tissue as a viable alternative matrix for PAH source apportionment. English sole and sediment

from near-urban sites reflected combustion-derived PAH sources, while those from the reference site were associated with a mix of combustion and petrogenic sources. Our results provide an important baseline in the midst of major project developments, document a priority contaminant threat to aquatic biota, and inform efforts to mitigate PAH discharges in coastal British Columbia.

2.07.P-We051 Microplastic Assessment in Two Coral Species, Acropora cervicornis and Acropora palmata, Along Florida's Reef Tract

Gretchen Bielmyer-Fraser[1], Taylor Bates[1] and Lauren Flick[1] (1)Jacksonville University

The emergence of microplastics (plastic polymers smaller than 5 mm in any dimension) as contaminants in marine environments has prompted increased efforts to understand their species-specific impacts. Corals are particularly vulnerable to microplastic contamination due to their role as filter feeders and their proximity to the coastline. This study aimed to determine the extent of microparticle contamination (including microplastics and other synthetic microparticles) in the threatened Caribbean corals, Acropora cervicornis and Acropora palmata, within the Florida Reef Tract, collected in 2025 and 2026. Twelve fragments of each species were processed using standardized digestion, filtration, microscopic analysis, and Fourier Transform Infrared (FTIR) spectroscopy. Synthetic microparticles were present in every sample, and microplastics were found in half of the samples. Among microparticles and microplastics detected, fibers were overwhelmingly predominant. Rayon accounted for the majority of the synthetic microparticles, followed by polyester, polyethylene, and nylon. Most microparticles were white or clear. These findings reinforce broader research showing that synthetic fibers, often originating from wastewater effluents, sewage outfalls, and textile sources, are a concern for coral reef organisms. This research will contribute to a growing body of knowledge on microplastic pollution in coral ecosystems and provide insight into potential mitigation strategies to protect the Florida Reef Tract's status as one of the most ecologically and economically important reef systems in the United States.

2.07.P-We052 Assessing the Effects of Organic Ultraviolet Filters on Coral Acropora tenuis Using an Acute Toxicity Assay and Transcriptome Analysis

Sakiko Nishioka[1], Kako Aoyama[2], Yuto Amano[1], Hiroshi Honda[1], Takahiro Suzuki[1], Toshiyuki Takagi[2] and Masayuki Yamane[1] (1)Kao Corporation, (2)The University of Tokyo

Coral reefs support high biodiversity but are threatened by global and local stressors. Organic ultraviolet (UV) filters used in sunscreen products have raised concerns about adverse effects on corals and have triggered precautionary restrictions in some regions. However, coral ecotoxicity data remain limited, partly due to the lack of standardized toxicity test guidelines for corals. Here, we evaluated the acute effects of five organic UV filters on reef-building coral Acropora tenuis: ethylhexyl methoxycinnamate (EHMC), bis-ethylhexyloxyphenol methoxyphenyl triazine (BEMT), diethylamino hydroxybenzoyl hexyl benzoate (DHHB), drometrizole trisiloxane (DTS), and ethylhexyl triazone (EHT). We conducted a 96-hour semi-static acute toxicity assay on coral fragments using a protocol adapted from Organisation for Economic Co-operation and Development (OECD) aquatic toxicity testing guidelines. Endpoints included quantitative color change assessed using a color chart combined with image analysis, maximum quantum yield of photosystem II (Fv/Fm) in symbiotic algae, and visual condition scoring. Given the low water solubility of these UV filters, test solutions were prepared by mixing and settling, and the mid-water fraction was used for exposure to minimize undissolved material. Test concentrations were analytically measured before and after each renewal. Across all five UV filters, no

significant changes in coral color, Fv/Fm, or visible condition were observed relative to controls under the test conditions. Time-weighted mean measured concentrations were near or above reported aqueous solubilities, indicating that exposures were conducted at solubility limits and that measured values may reflect accommodated concentrations rather than strictly dissolved fractions. Although environmental monitoring data for these UV filters are still limited, reported concentrations to date are generally far below the exposure levels tested in this study. In addition, transcriptome analysis by RNA sequencing of corals exposed to EHMC, which has relatively higher water solubility among the tested UV filters, revealed only two differentially expressed genes compared with solvent controls, supporting the absence of detectable acute effects under the test conditions. These findings suggest low acute hazard of the tested UV filters to adult A. tenuis at solubility limits and provide data to inform coral risk assessment and prioritization.

2.07.P-We053 First Insights Into Aliphatic and Polycyclic Aromatic Hydrocarbons (PAHs) in Hawksbill Turtle (Eretmochelys imbricata) Eggs From Persian Gulf

Sara Pouyande[1], Alireza Riyahi Bakhtiari[2] and Mahmoud Ghasempouri[2] (1)National Institute for Scientific Research (INRS), (2)Department of Environmental Science, Faculty of Natural Resources and Marine Science, Tarbiat Modares University

Petroleum pollution in marine ecosystems has raised great concern for both marine organisms and human health. The Persian Gulf, as a significant hotspot of petroleum pollution, is a crucial nesting area for hawksbill turtles (Eretmochelys imbricata) worldwide. In this work concentration level, source, and compositional profiles of polycyclic aromatic hydrocarbons (PAHs) and normal alkanes (n-alkanes) were analyzed in the yolk, albumen, and shell of hawksbill turtle eggs collected from 3 nests on the Persian Gulf coast of Iran. Twenty-eight PAHs and 19 n-alkanes were detected in samples. The highest levels of ΣPAHs and Σn-alkanes were found in yolk samples compared to the albumen and shell, possibly due to the high lipid content and lengthy duration of yolk formation. Comparable levels of pollutants were found in eggshells, indicating the potential for turtle eggshells to accumulate organic pollutants. The source of PAHs and n-alkanes in all samples primarily indicates petrogenic origin, suggesting extensive oil-producing activities and petroleum pollution in the Persian Gulf. Inter-nest variations in levels and profiles of PAHs and n-alkanes were observed in the eggs from the 3 nests, which might be related to the turtle's diets and migration patterns. This study provides the first monitoring data on organic pollutants for sea turtles in the Persian Gulf. More research is required in terms of monitoring petroleum biomarkers in turtle foraging grounds, maternal blood, and eggs in this region.

2.07.P-We054 Comparison of Sensitivities and Effects Between Freshwater and Marine Medaka Embryos Exposed to Oxygenated PAHs

Mirai Uchimura[1], Masatoshi Yamasaki[1], Emiko Kokushi[1] and Seiichi Uno[1] (1)Kagoshima University

Recently, oxygenated polycyclic aromatic hydrocarbons (OPAHs) have been detected in aquatic environment. Previous studies also reported several OPAHs induce developmental toxicities in freshwater fish embryos. Fish embryos are highly sensitive to chemical exposures and are useful models for evaluating developmental effects. However, most studies are based on freshwater fish, such as zebrafish and Japanese medaka, whereas information on marine fish embryos remains limited. Freshwater and marine fish may differ in their sensitivity to chemicals due to differences in developmental environments and physiological characteristics, including osmoregulatory systems.

In this study, we investigated the developmental toxicities of two OPAHs, benzanthrone (BAN) and anthrone (ATN), in the embryos of freshwater medaka (Oryzias latipes) and marine medaka (Oryzias javanicus). Furthermore, we examined the difference in sensitivity to OPAHs between these species. BAN is known as a dye intermediate and has been reported to exhibit immunotoxicity in mammals and also detected in urban aquatic environment. In contrast, ATN can generate reactive oxygen species through photo-oxidation, leading to cytotoxicity.
Embryos of both species were exposed to BAN at 4.6, 11, 29, 71, 178, and 446 μg/L and ATN at 50, 100, 200, 400, and 800 μg/L from 0 day post-fertilization until hatching (n=3, with each replicate consisting of 10 embryos). We recorded morphological abnormalities each day until hatching. In addition, we continued to observe until 3 days after hatching to evaluate mortality, time until hatching, and morphological abnormalities.
BAN exposure caused mortality and various morphological abnormalities in both species, and caused 100% mortality in ≥178 μg/L groups for freshwater medaka embryos, while ≥71 μg/L groups in marine medaka embryos. In freshwater medaka, all embryos exhibiting discoloration of oil droplets eventually died. Meanwhile, marine medaka embryos showed different abnormalities, such as congestion in the head and tail and heart edema, and all embryos exhibiting these phenotypes eventually died.
ATN exposure induced no remarkable effects in freshwater and marine medaka at all. These results suggest that ATN is possibly almost nontoxic to fish embryos.
These results suggest that marine medaka embryos may be more sensitive to BAN than freshwater medaka embryos and that BAN may affect these two Oryzias species through different toxic mechanisms.

2.07.P-We055 Antifouling Paint Particles (APPs) as a Source of Microplastics and Heavy Metals in Nova Scotia's Harbours

Ethan Geraci[1], Mark Mallory[2], Jennifer Provencher[3] and Ian Spooner[1] (1)Acadia University, Department of Earth and Environmental Science, (2)Acadia University, Department of Biology, (3)Environment and Climate Change Canada (ECCC)

Antifouling paint particles (APPs) are a class of microplastics (MPs) that form from the breakdown of antifouling paints during boat maintenance processes and from the general wear and tear of a coating. Modern antifouling paints commonly contain cuprous oxide as a primary biocide, but may also contain booster biocides including zinc oxide, zinc pyrithione, copper pyrithione, and copper thiocyanate. APPs and other forms of paint microdebris can be classified as MPs since many paints contain acrylic, alkyd, and epoxy resins, which function as binders. Paint particles have higher densities compared to conventional MPs (>2.0 g/cm3) and will accumulate the most in sediments. To date, there is a significant lack of studies that assess the concentration and spatial distribution of APPs in North American environments. Our research aims to address this knowledge gap by providing insight into the occurrence of APPs in Nova Scotia's harbours and boatyards. Our intention is to develop a holistic understanding of APP pollution according to factors such as sediment depth, the concentration of associated metals, harbour size, boat density, and tidal range. Summer 2026 field work will involve the sampling of harbours using a sediment gravity core followed by the extraction of MPs and APPs from retrieved sediments. We predict that APPs will occur the most in the surface sediments of harbours, particularly in the areas of a harbour where boats spend a considerable amount of time (e.g. near docks, moorings, and slipways). Analysis and identification of APPs will involve the use of physical characteristics (density, size, shape, and colour) and the application of X-ray fluorescence, Raman spectroscopy, and Fourier transform infrared spectroscopy (FTIR) to identify APPs based on their metal and polymer components. We

hope that the results of our research can contribute to global conversations on MPs and lead to future studies of APP pollution and ecotoxicity in Atlantic Canada.

2.07.P-We056 Assessing Ecotoxicological Risks of Pollutant Resuspension During Intertidal Rewilding: A Multi-Level, Multi-Species Approach

Audrey Bordaz[1], Joris Dourthe[1], Bruno Cognie[1], Bruno Jesus[1], Hervé Capiaux[2], Thierry Lebeau[2], Colleen Guinle[1], Clément Baratange[1], Philippe Rosa[1], João Pedro Coelho[3], Ana Isabel Sousa[3], Alexandra Petit[1], Thierry Lebeau[2], Vona Meleder[1], Aurore Zalouk-Vergnoux[1], Laurence Poirier[1] and Paul Deleris[1] (1)Nantes Université, Institut des Substances et Organismes de la Mer, ISOMer, UR 2160, F-44000 Nantes, (2)Nantes Université, Laboratoire de Planétologie et Géosciences, LPG, UMR CNRS 6112, F-44000 Nantes, (3)ECOMARE, CESAM—Centre for Environmental and Marine Studies, Department of Biology, University of Aveiro

The concept of "rewilding", a nature-based solution that is well established for terrestrial environments but still in its early stages for marine environments.
One of the aims of the REWRITE project (Funded by the European Union under Grant Agreement 101081357) is to assess the ecotoxicological risks associated with the resuspension of sediments during intertidal rewilding actions. Unlike existing studies, which focus on subtidal sediments (such as port dredging), this project centers on inter- or supratidal sediments, whose disturbance could release accumulated pollutants and disperse them along the land-sea gradient, thereby impacting marine ecosystems. The Corsept site (Loire Estuary, France), intended to be rewilded, and Aveiro's bay (Portugal), currently undergoing rewilding, served as models for this study.
Elutriates have been generated from sediments sampled in supratidal or upper intertidal areas. The elutriates were characterized based on their pollutant content (HAP, PFAS, pesticides and metals). To assess the impact of resuspended pollutants, a multi-level, multi-species approach was employed in mesocosms, involving three model organisms exposed to elutriates. Microalgae from the microphytobenthos, which represent primary producers, were assessed for stress and CO_2 uptake capacity via photophysiological testing. The diversity and metabolic functions of the associated bacterial community within this biofilm were analyzed via metabarcoding. Finally, the mussel (Mytilus galloprovincialis) was used to represent primary consumers. It underwent physiological analyses (clearance rate) and molecular assessments of oxidative and neurotoxic stress (enzymatic biomarkers), as well as untargeted analyses (lipidomics and mRNA sequencing transcriptomics) to evaluate metabolic impacts. The bioaccumulation of the pollutants in the Mytilus galloprovincialis model was also determined.
By integrating these approaches, this work provides a comprehensive analysis of the ecotoxicological risks linked to pollutant resuspension during intertidal rewilding, while developing a multidimensional assessment of the impacts on coastal ecosystems.

Disclaimer/Disclosure: The REWRITE project is funded by the European Union under Grant Agreement 101081357

2.07.P-We057 Dissolved Organic Matter Composition as a Potential Driver of PFAS Mobility and Partitioning in the Nueces/Corpus Christi Bay of Texas

Alyssa Wentzel[1], Tonoy Das[2], Kristin Nielsen[3] and Sankar Sasidharan[4] (1)No Affiliation, (2)Department of Environmental Engineering, Texas A & M University-Kingsville, (3)University of Texas Austin, (4)Department

of Wildlife, Fisheries, and Aquaculture

Per- and polyfluoroalkyl substances (PFAS) are widely documented in estuarine and coastal environments, where their transport and fate are influenced by interactions with dissolved organic matter (DOM). While previous studies have largely focused on bulk carbon metrics such as dissolved organic carbon (DOC), the influence of DOM composition on PFAS partitioning and mobility remains poorly constrained. This study investigates how DOM fractionation, aromaticity, and molecular weight can influence PFAS mobility in the dissolved phase or its partitioning to sediment phases at the Nueces/Corpus Christi Bay (Texas) test site. Surface water and sediment samples were collected from ten sites during May-April 2026 along the Nueces/Corpus Christi Bay. Four sites are terrestrial-influenced regions, while six sites are affected by wastewater (WW) outfalls, providing a gradient in DOM composition and sources. Preliminary characterization showed that WW impacted surface water sites revealed elevated DOC concentrations, but lower SUVA254 and E2:E3, indicating treatment processes are contributing less aromatic and higher molecular weight DOM. Non-WW sites were characterized with higher a254, SUVA254, and E2:E3, consistent with more aromatic and terrestrially influenced DOM sources. To move beyond bulk carbon measurements, excitation-emission matrix fluorescence spectroscopy coupled with parallel factor analysis (PARAFAC) has been used to identify dominant DOM components and characterize source-specific DOM signatures. PFAS concentrations measured in water and sediment samples will be correlated with both conventional DOM parameters (DOC, SUVA254, absorbance indices) and PARAFAC-derived components to establish quantitative relationships between DOM quality and PFAS occurrence, partitioning, and mobility. The resulting framework will improve understanding of how DOM composition influences PFAS environmental behavior and will support the development of predictive approaches for assessing PFAS transport in wastewater- and runoff-impacted coastal ecosystems.

Disclaimer/Disclosure: NRT-HDR: Transdisciplinary Research and Education for Air and Water Resources Solutions in Coastal Communities (TREAWS) #224453

2.07.P-We058 Evaluating a Cross-Species Prediction of Oil Toxicity in Marine Molluscs Using the Critical Target Lipid Body Burden

Ryan Rosniak[1], Danielle Philibert[2], Diana Chan[3], Kyle Artelle[4] and Ryan Prosser[1] (1)University of Guelph, School of Environmental Sciences, Guelph, ON, (2)Huntsman Marine Science Centre, St. Andrews, NB, (3)Heiltsuk Integrated Resource Management Department, Bella Bella, BC, (4)Heiltsuk Integrated Resource Management Department, Bella Bella, BC, Canada, AND State University of New York College of Environmental Science and Forestry, Department of Environmental Biology, Syracuse, NY, United States

Critical target lipid body burden (CTLBB) values can be used to determine the additive effects of narcotic chemicals at defined toxicological endpoints based on the compound's ability to bioaccumulate in organism lipid. There has been a growing interest in applying this concept to polycyclic aromatic compounds (PACs), the primary constituents found in complex oil mixtures believed to cause toxicity to aquatic life. Marine molluscs are important nutrient cyclers that are currently underrepresented when it comes to deriving species-specific CTLBBs. As a result of the 2016 marine diesel spill in the Haíłvaqv (Heiltsuk) First Nation of British Columbia, the Prosser research group in partnership with the Heiltsuk Integrated Resource Management Department established a CTLBB value for the Manila clam (Venerupis philippinarum). This species holds cultural and economic significance to the Nation, among other mollusc specieslike the endangered northern abalone (Haliotis kamtschatkana). As toxicity testing with H. kamtschatkana would not be ethical due to their

endangered status in Canada, this research aims to determine whether the CTLBB for V. philippinarum could accurately predict the toxicity of oil products to a variety of marine and freshwater mollusc species. This study performed testing with juvenile file ramshorn snails (Planorbella pilsbryi). Snails were passively dosed with a five PAC mixture (naphthalene, 1-methylnaphthalene, phenanthrene, dibenzothiophene, pyrene) spanning a range of octanol-water partition coefficient (logKOW) values and monitored for mortality over a 96-hour exposure. The observed toxicity in P. pilsbryi from exposure to the PAC mixture was then compared to the toxicity predicted for the PAC mixture by the CTLBB for V. philippinarum. The data generated from this study will inform predictions on the effect of oil spills on coastal ecosystems, which will then support risk mitigation in areas with high shipping volumes.

Finding Solutions to Salt Impacted Environments by Innovative Management and Risk Characterization

2.08.P-Tu059 Characterization of Chloride Exposure Levels and Ecological Risk in the Lake Winnipeg Watershed

Braedon Humeniuk[1], Chelsea Lobson[2], Jose Luis Rodriguez Gil[3] and Mark Hanson[1] (1)University of Manitoba, (2)Lake Winnipeg Foundation, (3)International Institute for Sustainable Development – Experimental Lakes Area

The concentrations of salts in freshwater systems have been increasing globally, resulting in concern of adverse and sustained ecological impacts. With numerous potential pathways for dissolved salts to enter surface waters (e.g., road de-icing, agriculture, wastewater effluents, and resource extraction), there is a need for high quality monitoring data to inform exposure assessment and modelling when making regulatory decisions for freshwater protection. Surface waters in Manitoba and the area around Lake Winnipeg (the world's 10th largest freshwater lake) are relatively unstudied, and we were interested in characterizing the current state of salinity and salinization, as evaluated through the lens of a community-based monitoring (CBM) program. In partnership with the Lake Winnipeg Foundation, CBM volunteers gathered 6069 water samples over five field seasons (2020-2024), from a total of 143 sites across Manitoba. The collected water samples were analyzed for chloride ion concentrations, and each sampling site was categorized by their dominant land-use (e.g., urban, rural municipality, agriculture, pasture, lake outlet, and forest) to determine the driving sources, as well as temporal trends of salinization in the watershed. During the five field seasons, multiple sites across differing land-uses exceeded the Long-Term Canadian Water Quality Guideline (CWQG) for the Chloride Ion (120 mg Cl-/L) based on time-weighted averages for each site, with 13%, 16%, 4%, 6%, and 6% exceedance rates in 2020 (n = 64), 2021 (n = 91), 2022 (n = 75), 2023 (n = 109), and 2024 (n = 111), respectively. There was a low acute risk of exceedance across sites; however, two urban and two rural municipality sites exceeded the Short-Term CWQG (640 mg Cl-/L) multiple times (n = 17) in all years except for 2022. The sites that experienced the greatest salinity levels were in rural municipalities within the Red River Valley and near the city of Winnipeg, Manitoba, suggesting that anthropogenic factors are likely driving exposure in these regions. Overall, this project will provide data to inform risk assessment, as well as identify a possible driver of ecological change in freshwater systems, while also enhancing public participation in their protection.

2.08.P-Tu060 Characterizing the Impacts of Salinization on Prairie Wetlands With

Outdoor Mesocosms To Assess and Improve Water Quality Guidelines

Braedon Humeniuk[1], Kailey Carrierè[1], Aashiya Sharma[1], Danika Harland[1], Roland Akinseye[2], Charles Knapp[2], Jose Luis Rodriguez Gil[3] and Mark Hanson[1] (1)University of Manitoba, (2)University of Strathclyde, (3)International Institute for Sustainable Development – Experimental Lakes Area

Salinization via chloride is a global threat to freshwater systems and is of pressing concern for vulnerable wetlands within the North American prairie pothole region. To assess the effectiveness of existing Canadian Water Quality Guidelines for chloride, we investigated the impacts of sodium chloride on freshwater ecosystems by using mesocosms monitored for 707 days (2023-2025). Outdoor mesocosms (~3000 L total volume) were established to simulate shallow prairie wetlands and treated with nine chloride concentrations in a regression design (linear on a logarithmic scale, n = 1), with controls (no salt added, n = 3). Treatments ranged from 22 to 2000 mg Cl-/L, which included the short- and long-term Canadian Water Quality Guidelines of 640 and 120 mg Cl-/L, respectively. Multiple endpoints were assessed to provide a weight of evidence approach, including the characterization of zooplankton, emergent insects, macrophytes, phytoplankton, and microbial communities. Overall, the relative abundance and diversity metrics in treatments as low as 39 mg Cl-/L were notably different from those in controls during the second year of monitoring, suggesting that the long-term Canadian Water Quality Guideline may not be sufficiently protective of lower trophic levels. Higher treatments experienced shifts in zooplankton community structure, with an increase in the proportion of salt-tolerant species over time. Furthermore, increasing chloride concentrations significantly reduced the growth and development of wild rice (Zizania palustris), with a 120-day mesocosm root mass EC50 value of 42 mg Cl-/L. Chloride inhibited bacterial nitrification, potentially allowing archaeal species tolerant to salinity to take over. It altered denitrification by hindering microbes involved in the final conversion of N2 gas, thereby allowing partial reduction of nitrate and nitrite, with implications for climate change, agriculture, and wetlands. These data will improve our understanding of the impacts of salinization on lower trophic levels, inform risk assessments, and help improve water quality guidelines for chloride salts in freshwater.

2.08.P-Tu061 Fathead Minnows (Pimephales promelas) Do Not Show a Significant Physiological Response to Chloride After 30 Day Exposure in Mesocosms

Elli Hung[1], Bradley Park[2], Braedon Humeniuk[1], Jose Luis Rodriguez Gil[2], Mark Hanson[1] and Kenneth Jeffries[1] (1)University of Manitoba, (2)International Institute for Sustainable Development (IISD)

The salinization of freshwater ecosystems is an important stressor to aquatic organisms. Much research has been done on the acclimation of marine and coastal fishes to different salinities, but less is known about these mechanisms in obligate freshwater species. Freshwater species can often tolerate moderate increases in salinity; however, it is unclear whether this is simply tolerating the changes in salinity by easing ion gradients or whether physiological adjustments are made such as alterations in gill morphology. To address this question, we studied the effects of salinity on the gene expression and histology of the freshwater species fathead minnow (Pimephales promelas) under field conditions. We exposed adult fathead minnows to 7 concentrations of chloride (measured concentrations of 23.55 to 532.4 ± 0.05 mg Cl-/L) in 3,000 L outdoor wetland mesocosms. These concentrations are consistent with what could be measured from surface runoff rapidly changing salinity levels in aquatic ecosystems with the maximum concentration being approximately the benchmark concentration for freshwater short-term exposure based on the Canadian Water Quality Guideline (CWQG) for chloride (640 mg Cl-/L). Fish were left undisturbed in these mesocosms for 30 days to feed on invertebrates and

organic matter to mimic their natural environment. At the end of the 30 day exposure, a gill arch was taken for gene expression analysis and whole fish were fixed for histology. To examine if osmoregulation was being impacted by chloride exposure, four genes encoding ATPase subunits (atp1a1b, atp1b1a, atp1a2a, and atp1b2a) were targeted and structural features of the gill were examined using histology in the control treatment (measured concentrations of 23.55 Cl-/L) and highest treatment (measured concentration of 532.4 mg Cl-/L). There was no difference in gene expression of any targeted osmoregulatory gene between the control and highest chloride treatment (control, n = 17; highest, n = 21). There was also no apparent difference in gill histology between the control and highest chloride treatment (for both treatments n = 10 male, n = 9 female). These results suggest that fathead minnows were not impacted by exposure to chloride as measured by changes in expression of ATPase genes or structural changes in the gill. Therefore, the CWQG benchmark seems to be protective of fathead minnows, but more research should be conducted on other freshwater fishes.

2.08.P-Tu062 Road Salt Contamination in the Vancouver Lower Mainland, and the Effects on Developing Pacific Salmon

Clare Kilgour[1], Carley Winter[1], Jack Hall[1], Colin Brauner[1], Ana Chará-Serna[2], Alan James[3], Nikki Kroetsch[4], Chris Wood[5] and Patricia Schulte[5] (1)University of British Columbia (UBC), (2)British Columbia Institute of Technology (BCIT), (3)Stoney Creek Environmental Committee (SCEC), (4)Department of Fisheries and Oceans Canada (DFO), (5)University of British Columbia

The application of road salt during winter months is a well-established driver of freshwater salinization across northern latitudes. Typically, road salt is transported by stormwater flow and with snowmelt, resulting in non-point source contamination of nearby freshwater streams. In the Vancouver Lower Mainland (VLM), road salt contamination events occur between November and March, coinciding with the period when Pacific salmon species such as coho (Oncorhynchus kisutch) and chum salmon (Oncorhynchus keta) return to spawn in urban freshwater streams. As a result, developing Pacific salmon may be exposed to road salt contamination during their earliest and most sensitive life stages. Through a community-based monitoring effort involving local stream steward volunteer groups and a network of almost 30 water quality data loggers, we found that concentrations of road salt in urban streams in the VLM can exceed British Columbia's acute guideline for chloride (600 mg/L Cl-) by up to 11-fold during pulsed contamination events. We further found that chloride contamination was most severe in more urbanized catchments. Interestingly, the amount of salt entering streams does not correlate with winter severity, and remains consistent, even during notably mild winters. Laboratory toxicity testing with three species of Pacific salmon have shown that the acute concentrations of road salt measured in local streams are lethal to developing Pacific salmon embryos, with sublethal effects on survivors. Our results demonstrate that road salt contamination poses a real threat to developing Pacific salmon in urban streams of the VLM (NSERC Alliance).

2.08.P-Tu063 Lymnaea stagnalis, the Great Pond Snail: Impacts of Salinity (NaCl) on Mortality, Reproduction, Internal Sodium Regulation, and Nitrogen Metabolism

Chris M. Wood[1], Yuli Mukohyama[1], Junho Eom[1], Maya Seethram[1], Lauren Zink[2] and Ora E. Johannsson[1] (1)University of British Columbia, (2)University of British Columbia

Lymnaea stagnalis is a common, holarctic species of slow-moving to still waters and is common in road-side ditches where it may be impacted by road-salt runoff. It has been used as a model organism in toxicology and

physiology. Our studies address the salinity tolerance of the snail with respect to survival, growth, reproduction, ion regulation, and metabolism. We exposed snails to a geometrically increasing set of sodium chloride (NaCl) concentrations within the range of 1.3 mM (nominally 0 mM) to 160 mM (i.e. 46 – 5680 mg Cl /L)

The acute (4-d) LC50 for juvenile snails (0.8 g) was 100 mM (93-105 C.L.) or 3550 mg Cl/L (3301-3727 C.L.), similar to literature values. However, in longer exposures (14-28 d), growth was negative at 80 mM (2840 mg Cl/L), indicating that snails exposed to such high concentrations of NaCl would not survive. Between 0 mM and 40 mM (1420 mg Cl/L), specific growth rate was stable and averaged 2.6 ± 0. 2 (36) %.day (mean ± SEM (N)). Snails at 40 mM did grow faster than those at lower salinities during the first week, but did not maintain this difference over time. Reproductive output (#eggs/g of snail) was affected by even lower salinities - 20-40 mM (710-1420 mg Cl/L). Soft-body sodium concentration increased in this same low range, and the % contribution of urea-N to total waste-N excretion (i.e. ammonia-N + urea-N) progressively increased at chloride concentrations above 10 mM.

Concentrations of chloride above 10 mM (355 mg/L) are detrimental to the health of this snail This concentration is below the acute Cl guideline for Canada (640 mg/L) but above the chronic guideline (120 mg/L) which provides the species some protection. Still, sublethal effects on smaller snails and interaction effects with other stressors need to be examined (NSERC Discovery; NSERC Alliance).

2.08.P-Tu064 Effects of Road Salt Exposure on Hexagenia limbata and Hexagenia rigida Hatching Success

Cecilia Goodin[1], Isabelle Monroe[2], Emma Garza[2] and Amanda Harwood[2] (1)Knox College, (2)Alma College

Road salts are frequently used throughout North America as deicing agents and commonly pollute surface water through runoff. This poses a threat to surrounding environments due to road salts' tendency to persist within their environment for up to months at a time. Previous studies have demonstrated ecosystem level effects on aquatic invertebrates, including mayflies. Hexagenia mayflies are highly sensitive to environmental pollution, including increased salinity levels, but play a vital role in maintaining freshwater quality and in aquatic food webs. However little is currently known about the impact of road salts on mayfly reproductive success. The objective of the current study was to evaluate the impact of road salt on the hatching success of Hexagenia limbata and Hexagenia rigida. Collected mayfly eggs were exposed to a range of environmentally relevant NaCl concentrations (and control) for 28 d post fertilization. The percentage of larvae hatched and hatch rate was determined for both species at a range of NaCl concentrations. The current study provides insight into how road salts, specifically NaCl, could impact the reproductive success of aquatic invertebrates like mayflies.

2.08.P-Tu065 Effect of Deicing Agent Exposure on Hyalella azteca Feeding Preferences

Isabelle Monroe[1], Emma Garza[1], Cecilia Goodin[2] and Amanda Harwood[1] (1)Alma College, (2)Knox College

The extensive use of road salts as deicers in cold climates has led to increased salinity in freshwater ecosystems. The subsequent increased salinity levels have potential negative effects on food availability and quality for aquatic invertebrates. Previous studies have determined that food quality can impact invertebrate’s tolerance to road salts and other stressors. However, recent research found leaves conditioned in deicing agents were not

significantly different in mass than those conditioned in control water. While diet may impact Hyalella tolerance to road salts, it is still unknown if food choice is impacted. The objective of the current study was to determine if food or animal exposure to deicing agents impacted Hyalella azteca food choice. Acer saccharum leaf discs were conditioned in culture water for 14 d, followed by 96 h exposure to various concentrations of deicing agents and placed in beakers with Hyalella for 96 h. Feeding preferences were determined by calculating change in mass. This allows us to better understand the relationship between salinization and diet.

2.08.P-Tu066 Effects of NaCl and Beet Deicer on Acer saccharum Leaf Decomposition

Emma Garza[1], Cecilia Goodin[2], Isabelle Monroe[1] and Amanda Harwood[1] (1)Alma College, (2)Knox College

Runoff from road salts impacts both terrestrial and aquatic environments, but little is known about road salts' effects on leaf decomposition. Previous studies have determined that road salts impact the shredding rates of Hyalella azteca, but the mechanism for this phenomenon is not understood. The objective of the current study was to evaluate the effect of deicing agents on the decomposition of Acer saccharum, a leaf commonly found in aquatic systems. Leaf discs were conditioned in control water or deicing agent solutions for three weeks followed by 48 hr exposures to environmentally relevant sodium chloride or beet deicer concentrations. The effects of salts were determined by comparing the initial weight post-conditioning and final mass. The findings from the current study should provide insight into whether deicing agents affect the leaf's decomposition.

2.08.P-Tu067 Soil-Based Seed Germination Responses to Treated Produced Water

Efe Isukuru[1], Jordan Crago[1] and Todd Anderson[1] (1)Texas Tech University

Oil and gas extraction generates large volumes of chemically complex, highly saline wastewater known as produced water (PW), with projected increases expected alongside expanding production in arid regions such as the Permian Basin. Current disposal practices largely rely on deep-well reinjection, which has been associated with increased seismicity and potential for groundwater contamination through subsurface seepage, indicating the urgent need for sustainable treatment approaches that enable beneficial PW reuse. A range of treatment strategies, particularly those incorporating desalination processes, must be systematically evaluated to determine their effectiveness in producing effluents that are suitable for non-potable reuse applications. In this study, we obtained produced water samples that had undergone various forms of treatment (membrane desalination, distillation, thermal desalination, and granulated activated carbon) to evaluate their potential for reuse (irrigation). Previously, we conducted a seed germination assay following OECD Guideline 208 using seven plant species to assess germination responses to treated PW. The study demonstrated substantial germination success, with tolerance ranking observed as Wheatgrass = Radish > Soybean > Sorghum > Pinto Bean > Alfalfa > Cotton, indicating species-dependent differences in tolerance to various treated PWs. Subsequently, we extended the study to a soil-based germination system using sandy loam soil to further evaluate the effects of treated PW on seed germination and early plant development under conditions that better simulate agricultural settings. In the soil-based system, tolerance ranking was observed as Sorghum > Wheatgrass > Soybean = Cotton > Radish > Pinto Bean > Alfalfa. Interestingly, several plant species that exhibited poor germination performance in the initial assay demonstrated improved germination and early growth in the soil-based system, suggesting that sandy loam soil may have attenuated and/or buffered residual ionic and dissolved constituents in the treated PW through soil-solute interactions, thereby reducing phytotoxic

and osmotic stress during germination.

From Research to Action: The Potential of eDNA and eRNA in Ecotoxicology

2.09.T-01 Oozing Confidence: Progress in eDNA/eRNA Implementation Through Standards, Global FAIR Guidelines, and Proficiency Testing

Caren C. Helbing[1] and Valerie S. Langlois[2] (1)University of Victoria, (2)Institut national de la recherche scientifique

As many creative environmental DNA (eDNA) and environmental RNA (eRNA) applications find their way into the conventional environmental assessment and monitoring toolboxes, the need for identifying competent, quality implementation is paramount as is supporting a standardized data and metadata platform. Interoperability of eDNA/eRNA data among projects and databases is recognized as key to reducing data sharing barriers and maximizing utility for making meaningful decisions regarding natural resources and waste management at community and regulatory levels. This presentation covers the recent progress made through large-scale projects such as iTrackDNA to address key components to enhance confident use of eDNA/eRNA data through the creation of national and international standards and global guidelines for making data FAIR - Findable, Accessible, Interoperable, and Reusable. We present the latest progress on the development of an eDNA proficiency testing framework to systematically verify that a laboratory can produce accurate, reliable, and reproducible results under relevant conditions. Together, these advances help pave the way for confident use of powerful eDNA/eRNA tools to determine organismal to population to ecosystem health.

2.09.T-02 Monitoring Biodiversity in Nunavik Using Environmental DNA: A Collaborative Approach in Northern Quebec

Fidji Sandre[1], Julie Couillard[1], Tuan Anh To[1], Rachel Hussherr[2], Geneviève Dubois[2], José Guerin-Lajoie[2] and Valérie Langlois[1] (1)INRS, (2)UQTR

Under the influence of climate change, aquatic and terrestrial ecosystems in northern Québec are undergoing rapid transformations, affecting biodiversity that is essential to ecological functions and to the livelihoods of local communities, particularly Inuit communities. However, the vastness and remoteness of the territory limit the implementation of regular wildlife monitoring using conventional approaches. In this context, environmental DNA (eDNA) offers a particularly well-suited alternative, enabling the non-invasive detection of species from filtered water samples, with high sensitivity and logistics compatible with northern conditions.

Between 2024 and 2025, two helicopter-based sampling campaigns were conducted across the watersheds of the Koroc and George rivers, complemented by data collection carried out during Science and Culture camps within the Imalirijiit project area, in close collaboration with the community of Kangiqsualujjuaq. A non-targeted metabarcoding approach was used to characterize aquatic faunal diversity, identifying more than 26 species, while targeted qPCR analyses enabled the detection of emblematic and locally important species such as Arctic char, Atlantic salmon, seal, beluga, beaver, black bear, and caribou. Variations in detection were observed between sampling campaigns and appear to be related to environmental, spatial, and phenological factors.

This project highlights the potential of eDNA for monitoring northern biodiversity and underscores the importance of collaborative research integrating scientific and local knowledge.

2.09.T-03 Spawning Dynamics of Oolichan (Thaleichthys pacificus) in Haisla Territory: Annual eDNA Monitoring and Implications for Indigenous Stewardship

Michael Allison[1], Meredith Pochardt[1], Brenda Bouzane[2], Mike Jacobs[2], Morgan Hocking[3], Steve Sharron[3], Adam Lewis[3], Ali Mirabzadeh-Ardakani[4] and Caren Helbing[1] (1)University of Victoria, (2)Haisla Nation, (3)Trinity Consultants Canada, (4)Mérieux NutriSciences

Oolichan (Thaleichthys pacificus), known as záxʷen in the Haisla language, are anadromous smelt that support important ecological and cultural values along the Pacific coast of North America. Despite their significance to coastal ecosystems and Indigenous communities, including the Haisla Nation of central British Columbia, the distribution, timing, and abundance of Oolichan spawning, and the drivers behind recent population declines, remain understudied. Environmental DNA (eDNA) offers a sensitive, non-invasive, and scalable alternative to conventional survey methods such as mark-recapture, enabling detection of species presence and relative abundance across broad spatial and temporal scales. Here, we present findings from a collaborative eDNA monitoring program applying quantitative PCR (qPCR)-based targeted detection to map Oolichan spawning activity across 13 rivers from 2019 to 2026. Haisla Traditional Ecological Knowledge (TEK) informed study design, run timing, and interpretation of eDNA signals in culturally and ecologically meaningful context. Daily sampling in the Kemano River provided fine-scale resolution of eDNA concentration dynamics and adult behaviour throughout spawning runs. Run initiation varied by over two weeks across years (March 14 – April 1). Oolichan were consistently detected in rivers identified through TEK, though not in every year, underscoring the value of multi-year monitoring. The highest eDNA abundances were recorded in the Kemano River, where community fisheries remain active, and peak signals aligned closely with TEK-informed accounts of spawning activity. In contrast, Oolichan eDNA signals in the Kitimat River, historically a principal harvest site, were low, aligning with observations of few spawners since the population collapse in the 1990s. This work demonstrates that integrating eDNA technology into monitoring programs allows the accurate indexing of abundance over time with greater efficiency and lower cost than with existing methods, empowering Indigenous stewardship and, in this case, supporting Haisla Nation in the recovery and restoration of an ecologically and culturally significant species.

Disclaimer/Disclosure: Funding was provided by LNG Canada through a Complementary Measures Research Program. Additional financial support was provided by Mitacs, the Natural Sciences and Engineering Research Council of Canada (NSERC), and Rio Tinto.

2.09.T-04 Characterizing Environmental DNA Transport and Seasonal Dynamics To Improve Salmon Enumeration During Migration

Geoffrey Su[1], Melissa Shirey[2], Megan Spooner[2], Michael Allison[3], Mark Louie Lopez[3], Jordan Beblow[2], Kevin Koch[2], Jeffrey Anderson[4], Mark Cleveland[2], Caren Helbing[3] and Vicki Marlatt[1] (1)Simon Fraser University, (2)Gitanyow Fisheries Authority, (3)University of Victoria, (4)Geomorphic Environmental Services

Environmental DNA (eDNA) is a robust and effective tool for detecting aquatic species presence and habitat

use using targeted quantitative PCR assays. Expanding eDNA applications to salmon enumeration, however, requires site-specific calibration to account for downstream transport, persistence, and spatial-temporal variation in natural systems. Here, we combined a controlled in situ eDNA release experiment with seasonal field monitoring to better understand eDNA transport dynamics and improve interpretation of eDNA signals during migration.

A controlled release of 1189 g of homogenized Pink Salmon tissue was conducted in the Kitwanga River, and triplicate eDNA concentrations were quantified at 100, 1000, 2150, and 4800 m downstream at seven time points following release (15 s to 120 min). At 100, 2150, and 4800 m, eDNA was also monitored weekly throughout the adult migratory season for four Pacific salmonid species: Pink, Chinook, Coho, and Sockeye Salmon.

The controlled release experiment revealed distinct eDNA transport patterns, with peak eDNA concentrations at 1, 30, 60, and 120 min at the 100, 1000, 2150, and 4800 m sites, respectively. Wilcoxon signed-rank tests also identified above-background eDNA concentrations at 2 and 5 min at 100 m, and at 60 and 120 min at 1000 m. Pink salmon eDNA remained detectable at all sites 120 min following release, demonstrating substantial downstream transport and persistence across the 4.8 km study reach.

Seasonal monitoring showed elevated salmonid eDNA concentrations during pre-migratory periods for Chinook, Coho, and Sockeye Salmon, with Coho and Sockeye eDNA declining following migration onset. During migration, positive linear or polynomial relationships were observed between eDNA concentration and fish counts for all species. Least-squares regression ANOVA with post-hoc Tukey's HSD tests ($\alpha < 0.05$) identified significant spatial differences in eDNA concentrations among sites, particularly during post-migratory periods for Pink and Coho Salmon, as well as during peak migration periods for Chinook, Coho, and Sockeye Salmon.

Together, these findings demonstrate that controlled eDNA transport experiments can improve interpretation of seasonal field eDNA patterns and support the development of spatially informed salmon enumeration models. The pronounced variation in eDNA concentrations across 4.8 km highlights the importance of sampling site selection when applying eDNA methods to migratory salmon monitoring.

2.09.T-05 Establishing a Baseline Biodiversity Assessment of the York River (Quebec, Canada) Using Multi-Marker eDNA Prior to the Dewatering of a Copper Mine

Alexandre J. Thibodeau[1], Julie Couillard[1] and Valerie Langlois[1] (1)National Institute for Scientific Research (INRS)

A major copper mine in Murdochville (Quebec, Canada) on the ancestral, unceded territory of the Mi'gmaq/Gespe'gewa'gi Nation, requires the dewatering of the former open pit mine to conduct exploratory works , resulting in the discharge of millions of cubic meters of water into the York River watershed, containing a high ecological and socio-cultural importance that supports Atlantic salmon (Salmo salar) populations. Establishing a robust pre-dewatering biological baseline is essential for detecting any potential future impacts on aquatic biodiversity. Such baseline data are necessary to support evidence-based environmental assessment, long-term monitoring, and adaptive management by environmental regulators, Indigenous communities, and industry stakeholders.

Passive samplers were deployed across 16 sites during summer 2025 and retrieved after 24 h of exposure. Two universal primer sets targeting the cytochrome c oxidase subunit I and mitochondrial 12S rRNA genes were

used to investigate macroinvertebrate and fish communities, respectively. Taxonomic assignments were performed via BLAST searches against the NCBI database using the BARQUE pipeline. Community composition analyses were performed on presence/absence matrices using Jaccard dissimilarity, PERMANOVA, and indicator species analysis.

Community composition differed significantly across site categories : upstream Mine Gaspé influence, under mine influence and tailings (including Murdochville wastewater effluent), and downstream of Mine Gaspé influence. Bioindicator Ephemeroptera, Plecoptera, Trichoptera (EPT) taxa were nearly absent in sites under mine influence (< 1% of reads), whereas they represented more than > 39% of reads. Indicator species analysis identified 18 significant taxa across both genetic markers, including S. salar and several pollution-sensitive EPT species exclusively associated with downstream assemblages.

Together, these findings establish the foundation of an operational monitoring framework and identify priority taxa for future surveillance during and after dewatering. This study demonstrates the value of using multi-marker environmental DNA (eDNA) as a non-invasive and decision-relevant tool for environmental impact assessment in mining ecotoxicology. Further work will expand taxonomic coverage through the inclusion of additional biodiversity markers and incorporate targeted dPCR assays to quantify selected taxa of ecological and regulatory importance.

Disclaimer/Disclosure: Funding was provided by an NSERC Alliance grant (no. 10796), with co-funding from Métaux Osisko and the Atlantic Salmon Conservation Foundation (ASCF).

2.09.T-06 Environmental DNA for Early Detection of Invasive Species and Biodiversity Characterization in Urban Environments

Catherine Dubuc[1], Fidji Sandre[2], Hugo Asselin[3] and Valerie Langlois[1] (1)National Institute for Scientific Research (INRS), (2)Water Environment and Urban Systems Laboratory (LEESU), (3)Université du Québec en Abitibi-Témiscamingue (UQAT)

Environments are increasingly disturbed due to anthropogenic pressures, which alter ecological communities and promote the establishment of invasive species. Assessing ecosystem health relies on monitoring bioindicators and invasive species, but traditional methods are time-consuming and depend on taxonomic expertise that is becoming increasingly scarce. The use of environmental DNA (eDNA), genetic material left by organisms in their surroundings, offers a complementary and non-invasive approach to monitoring biodiversity in disturbed environments.

The aim of this study is to assess the potential of eDNA for the detection of invasive species and the characterization of biodiversity in lakes subject to varying levels of anthropogenic pressure in Rouyn-Noranda (Quebec, Canada). Water samples were collected from recreational lakes, biodiversity reserve lakes, and the municipal water intake, all located at varying distances from a pollutant-emitting industry.

Metabarcoding analyses provided a broad overview of the biodiversity present in these lakes, while more targeted quantitative polymerase chain reaction (qPCR) analyses were used to assess the presence or absence of Bythotrephes longimanus, an invasive crustacean recorded in the region.

Preliminary results indicate greater biodiversity in the biodiversity reserve lakes, but also in some recreational lakes, with the presence of several bioindicator species such as mayflies. No B. longimanus DNA was detected in any of the lakes sampled, indicating that preventive protection measures would still be timely. Further analyses will be conducted in 2027 on additional water bodies, targeting more bioindicator species and refining the results obtained in 2026.

This study is also being carried out in Petit-Saguenay (Quebec, Canada) focusing on species of emblematic importance for recreational fishing, such as brook trout and Arctic char. The results specific to each municipality will provide them with an overview of the health status of their ecosystems and support the planning of protected areas.

From Research to Action: The Potential of eDNA and eRNA in Ecotoxicology

2.09.P-Tu032 Environmental RNA as a Non-Invasive Tool To Track Thyroid Hormone-Induced Metamorphic Changes in American Bullfrog

Mark Louie Lopez[1], Marin Crane[1], Emma Field[1], Haley Kuecks-Winger[1] and Caren Helbing[1] (1)University of Victoria

Environmental RNA (eRNA) offers a promising non-invasive approach for monitoring physiological responses in aquatic organisms exposed to endocrine-disrupting chemicals. In amphibians, thyroid hormone (TH) signaling controls metamorphosis, making it a useful system for evaluating molecular responses to exposure. Here, we tested whether the use of eRNA from water samples collected in a microcosm exposure experiment could reflect transcriptional changes observed in American bullfrog (Rana catesbeiana) tadpole back skin during TH exposure, a common wastewater contaminant. We compared expression patterns of common normalizer genes with TH-responsive gene transcripts. Using reverse transcriptase quantitative polymerase chain reaction (RT-qPCR), more abundant normalizer transcripts (ribosomal protein L8 [rpl8], elongation factor 1-alpha [eefa], and ribosomal protein S10 [rps10]) and physiological markers were associated with epithelial tissues, including Rana larval keratin 1 (rlk1) and fatty acid-binding protein 2 (fabp2), showed similar expression patterns in water-derived eRNA and tadpole back skin samples. However, we observed inconsistent detection of lower-abundance transcripts typically associated with a TH-induced response (e.g., TH-receptor alpha/beta (thra/thrb), TH-responsive basic leucine zipper protein (thibz)) in environmental RNA samples. These preliminary results suggest that eRNA can be useful for detecting selected physiological responses in amphibians exposed to endocrine-disrupting chemicals using more abundant TH-responsive bioindicators. This work supports further development of eRNA as a non-invasive biomonitoring tool for assessing organismal health and thyroid hormone-mediated developmental change.

2.09.P-Tu033 Validation of eDNA Metabarcoding as a Tool To Evaluate Invertebrate Communities With Wild Rice Restoration

Alexandra Giuliano[1], Lisa Peters[2], Madeline Stanley[2], Krista Robertson[2], Morgan Anderson[2] and Vince Palace[2] (1)University of Manitoba, (2)IISD Experimental Lakes Area (IISD-ELA)

The spread of the invasive hybrid cattail (Typha x glauca) is negatively impacting wetland ecosystem health. Wetland biodiversity and ecosystem functions suffer in the presence of invasive cattails, which outcompete native aquatic plants, reduce fish nursery areas and habitat, alter benthic invertebrate community structures, disrupt nutrient cycling, and reduce dissolved oxygen levels. Cattail management and wild rice (Zizania palustris) reestablishment are important to Indigenous communities, who better know it as Manoomin, because it is a sacred food source with historical, medicinal, and ceremonial significance. This study, in collaboration with the Makate Waagamichiwanang Gakinaa'maatiwin Youth and Family Wellness camp, monitored wetland ecosystem health following the removal of invasive cattails and the reseeding of wild rice by evaluating changes in benthic invertebrate communities, plant communities, water quality, and sediment chemistry in 2025 and 2026. Three wetland plots (3 x 5m) were treated with cattail cut-to-drown management followed by a wild rice seeding ceremony in the fall of 2025, and three remained unmanaged. Benthic invertebrate communities were collected using leaf litter bags for morphometric analyses, and water and sediment were collected for environmental DNA (eDNA) metabarcoding to be analyzed on an Oxford Nanopore MinION ™ sequencer. The feasibility of using eDNA metabarcoding for benthic invertebrate community analysis will be evaluated by comparing the results of both methods. This study will contribute to the growing research on eDNA and its feasibility as a fast, cost-effective, and precise method for benthic invertebrate community analysis. Reintroducing wild rice can improve wetland ecosystem health, restore traditional Indigenous foods, and promote the integration of Indigenous and Western knowledge in scientific research.

General: Aquatic Toxicology, Ecology and Stress Response

2.10.P-We098 Hydrogen Sulfide in Biscayne Bay: Spatial Variability and Potential Links to Ecological Stress

Ryan Simone[1], Luis Bordin[2], Kassidy Troxell[2], Maria Guerra de Navarro[2], Ebuka Emenike[2] and Piero Gardinali[3] (1)Wesleyan University, (2)Florida International University, (3)Florida International University (FIU) Institute of Environment

Hydrogen sulfide (H_2S) is a reduced sulfur compound produced under oxygen-limited conditions in aquatic environments and is a known neurotoxin and respiratory inhibitor. In coastal systems, H_2S can accumulate in sediments and diffuse into overlying waters, where elevated concentrations may have detrimental effects on aquatic life and water quality. North Biscayne Bay has experienced recurrent fish kills and seagrass die-offs associated with nutrient pollution, hypoxia, poor water circulation, and high levels of dissolved organic matter in recent years. However, the potential role of H_2S in contributing to these environmental events remains unexplored. We hypothesize that H_2S production and accumulation are enhanced in areas with elevated organic matter, low oxygen conditions, and limited water exchange, and that elevated H_2S concentrations entering the water column will contribute to localized ecological stress. Sediment cores and their overlaying waters were collected from different locations across North Biscayne Bay and Little River, representing different degrees of anthropogenic influence and environmental conditions. H_2S concentrations were measured in sediment cores

and overlying waters using a Unisense hydrogen sulfide sensor, enabling high-resolution characterization of sulfide variability across sites. Differences in H_2S concentrations among bay sites and tributaries were assessed, and potential correlations between H_2S concentrations and environmental factors were evaluated. This study advances understanding of Biscayne Bay's sulfur cycling and biogeochemical processes and provides insight into potential associations between H_2S, ecosystem stress, and fish mortality. By calculating the potential for H_2S production, the results will support long-term water-quality monitoring and inform management strategies in the Bay.

2.10.P-We099 Bioaccumulation of Drugs of Abuse in Rainbow Darter (Etheostoma caeruleum): Validation of Lipid Methods for Small Native Fish

Milica Kecman[1], Diana Cardenas[1], Jeremy Hoare[1], Rachel Dawe[1], Reilly Lavery[1], Olivia Koprich[1], Leslie Bragg[1] and Mark Servos[1] (1)University of Waterloo

The bioaccumulation of a variety of neuroactive chemicals, including drugs of abuse, are being investigated in a small native fish species (Etheostoma caeruleum, rainbow darter). However, accurate measurement of lipid content in aquatic organisms is essential for environmental assessments and for enabling meaningful comparisons among samples (e.g., normalizing contaminant bioaccumulation). Traditional methods for lipid determination, like the Folch or Bligh-Dyer gravimetric methods, are often not suitable for small-bodied organisms due to their relatively large tissue mass requirements. To address this limitation, microassay-based approaches that require less tissue while maintaining analytical accuracy and reproducibility are needed. The sulpho-phospho-vanillin (SPV) assay is a micro-colorimetric method that has been successfully applied to microorganisms, microalgae, and various biological tissues. In this assay, lipids are extracted using a chloroform: methanol mixture and subsequently heated to 95°C with sulfuric acid. Addition of a phosphoric acid-vanillin reagent produces a pink chromophore with maximum absorbance at 540 nm. The objective of this study is to optimize the SPV assay for application to small-bodied wild fish and to evaluate spatial variation in lipid content relative to wastewater inputs. Fish residing downstream of wastewater treatment plants (WWTP) typically have increased condition and may exhibit differences in lipid content compared to those upstream. Darters were collected from a river in southern Ontario associated with a municipal WWTP: approximately 5 km upstream and 1 km downstream of the effluent discharge. This research will assess the feasibility of adapting the SPV method for small-bodied wild fish and improve understanding of lipid storage in aquatic organisms. Lipid normalization in bioaccumulation studies involving high-risk substances (i.e., drugs of abuse) is expected to reduce variability among samples and improve the accuracy of contaminant trends (in ongoing lab and field studies) while supporting more robust ecological risk evaluations

2.10.P-We100 Fish Size and PFAS Concentration in Maine Game Fish

Isaac Shepard[1] and Tom Danielson[1] (1)Maine Department of Environmental Protection

The accumulation of PFAS in freshwater fish is well documented and can pose a risk to human health when contaminated fish are consumed by recreational anglers or sustenance fishers. While much attention has been spent on understanding how different kinds of PFAS bioaccumulate in fish, less work has been done on how abiotic and biotic factors can affect PFAS accumulation in these organisms. To start understanding the drivers of variation in PFAS concentrations in freshwater fish we conducted a field survey in Maine from 2021 through 2024. In this study we collected fish and water samples for PFAS analysis from a variety of lakes and rivers

throughout the state of Maine. The sites we selected spanned a gradient of potential exposures and often included areas that are popular among anglers. We sampled four different game fish species including brook trout, black crappie, largemouth bass, and smallmouth bass. Angling was our primary method of sample collection and upon capture, we weighed and measured each fish. We obtained fish tissue PFAS concentrations from composite samples analyzed by SGS AXYS and water PFAS concentrations from grab samples analyzed by Pace Analytical. Using linear mixed effects models, we showed that for all four species, after accounting for the concentration of PFOS in the water (which explained most of the variation in fish PFOS concentrations), longer fish tended to have higher PFOS concentrations than shorter fish of the same species. Preliminary analyses indicate that that pattern may hold for other types of PFAS as well. While longer fish tended to have higher PFOS concentrations within species, this was not always the case among species. In rivers, larger-bodied species like largemouth and smallmouth bass had higher PFOS concentrations than smaller species like brook trout. However, in lakes, the smaller-bodied black crappie often had higher PFOS concentrations than the two larger bass species. The mechanisms behind this pattern are not immediately evident and may be caused by other, species-specific factors such as diet and metabolism.

2.10.P-We101 Assessment of Trace Metal Uptake and Response in Elodea densa and Elodea canadensis From Potomac River Sedimentation

Hannah Reents[1], Leanna Giancarlo[1] and Tyler Frankel[1] (1)University of Mary Washington

Trace metals can originate from a variety of anthropogenic sources including industrial, agricultural, and mining activities, and may cause adverse ecological effects in aquatic systems. Aquatic plants can be used to assess and potentially remediate trace metal contamination, including the submerged macrophytes Elodea canadensis and Elodea densa. Because Elodea species are known to accumulate metals, they are strong candidates for trace metal uptake and plant stress assays. The goals of this study were to: 1) determine trace metal concentrations in sediments collected from seven locations along the Potomac River and its tributaries, 2) evaluate trace metal uptake in E. canadensis and E. densa after 9 days of sediment exposure, and 3) assess plant stress responses using living cell and chlorophyll analyses. Sediments were collected from 10 sites along the Upper Potomac River and tributaries and analyzed for trace metal content (Ag, Al, As, B, Ba, Bi, Ca, Cd, Co, Cr, Cu, Fe, Ga, K, Li, Mg, Mn, Na, Ni, Pb, Sr, Tl, Zn) using inductively coupled plasma optical emission spectrometry (ICP-OES). E. canadensis and E. densa were grown in two inches of field-collected sediment while fully submerged in water. Plants were maintained in an incubator at 21°C under a 16:8 hour light:dark cycle for 9 days. At the end of the exposure period, leaves were randomly selected from each plant for living cell and chlorophyll analyses. Plants were then separated into tips, roots, and shoots, oven-dried, and digested using 3 mL of ultra-pure nitric acid and ultra-pure hydrogen peroxide. Following digestion, samples were analyzed by ICP-OES. For living cell analysis, leaves were submerged for 30 min in an aqueous working solution of 50 μg mL^{-1} propidium iodide and examined using epifluorescence microscopy. Chlorophyll analysis was conducted by homogenizing leaves in cold 80% acetone with approximately 0.05 g $MgCO_3$, bringing the extract to a known volume, and measuring absorbance using a Hach DR1900 with 80% acetone as the blank. Although this study is ongoing, we expect to observe 1) increased trace metal accumulation in roots and new-growth tips of Elodea exposed to contaminated sediments and 2) increased cell death and chlorophyll loss in plants grown in more highly contaminated sediments.

2.10.P-We102 Larval Microfibre Ingestion but Limited Ontogenetic Transfer in Chironomus dilutus

Colleen Wardlaw[1], Karen Kidd[1] and Ryan Prosser[2] (1)McMaster University, (2)University of Guelph

Microfibres are ubiquitous contaminants in aquatic environments, where their small size and persistence facilitate uptake by aquatic insects. This raises concerns about their effects and retention across life stages, with potential consequences for aquatic-terrestrial transfer to riparian predators. This study assessed microfibre ingestion, ontogenetic transfer, and potential life stage dependent responses in Chironomus dilutus. Chironomus dilutus were exposed to four microfibre types (red polyester, blue polyester, green acrylic, and pink polypropylene) at concentrations of 0, 50, 500, and 5000 microfibres/L delivered via a Nutrafin-cereal grass slurry in a full life-cycle exposure conducted over 56 days. Across all exposures, no significant effects on survival or emergence (success, timing, or sex ratio) were observed; however, the highest concentration (5000 microfibres/L) of polyester microfibres showed greater uptake than other microfibre types. Microfibres were frequently detected in larvae (20.8-53.3% for red polyester, 7.7-38.9% for blue polyester, 20% for green acrylic and 5.3-15% for pink polypropylene), with reduced occurrences in pupae, adults, and exuviae, indicating life stage dependent differences in retention, but limited evidence for consistent transfer through aquatic-terrestrial food webs. Although overall detections were low and no toxicity was observed, the persistence of some fibres into later life stages suggests that emergent insects may still act as vectors for microfibre movement into terrestrial food webs. These findings highlight the importance of considering ontogenetic processes when evaluating cross ecosystem contaminant transfer and the ecological implications of microfibre pollution.

2.10.P-We103 Investigating Suspected Hazardous Algal Blooms (HABs) in a Municipal Tertiary Treatment Wetland

Sarah Harmon[1] (1)University of South Carolina Aiken (USCA)

This project pertains to an investigation of cyanobacteria and their associated toxins in a constructed wetland receiving treated municipal sewage as a final treatment step before effluent is released to a permitted outfall on the Savannah River near Augusta, Georgia (USA). We are using a combination of microscopic algal identification, toxin assessment through phosphatase inhibition, pigment measurement, and the presence/quantification of cyanobacterial genes related to toxin production. Over the last year, 23 samples were collected from 5 of the wetland cells after visual inspection indicated floating foam, scum, or mats typically associated with nuisance cyanobacterial blooms. For each sample, the ratio of phycocyanin to chlorophyll-a was determined using basic pigment extraction and fluorimetry; microcystin was quantified using phosphatase inhibition assays; and a third tier of analysis included DNA extraction and qPCR to quantify total cyanobacterial gene copies (CYAN 108F/ 377R), total Microcystis genes (cpcA), and those cyanobacteria with the mcyB toxin gene. Of the 23 samples, 13 exhibited concentrations of phycocyanin in excess of chlorophyll, in ratios that ranged from 1.1 to 21. These results were further corroborated by qPCR which showed that cyanobacterial genes were present in those samples with elevated phycocyanin, and that there was a positive correlation between the number of cyanobacterial gene copies and the concentration of phycocyanin. However, only six samples were positive for the presence of the Microcystis gene (cpcA), and none contained the mcyB gene that is indicative of toxin production. Furthermore, phosphatase inhibition assays failed to detect microcystin in any of the samples. Most recently, microscopic algal identification is pointing toward he possibility that cylindrospermopsin-producing species may be present in some of the floating mats, so this work

will expand to include quantification of these toxins using ELISA. We continue to monitor this area in response to concerns that cyanobacteria and their toxins may be escaping this constructed treatment wetland to potentially impact downstream areas of this watershed.

2.10.P-We104 The Glitter Diet: PMMA-Based Microplastics Disrupt Skeletal Development and Delay Ossification in a Neotropical Frog

Felipe Micali Nuvoloni[1], Ana Julha de Almeida Santos[1], Ana Lívia Paixão[1], Maria Cristina Borges[1] and Luiz Norberto Weber[1] (1)Universidade Federal do Sul da Bahia

Microplastics (MPs) are pervasive pollutants in aquatic ecosystems, yet their developmental effects on Neotropical amphibians remain poorly understood. Although recent studies have reported MP contamination in anurans, the sublethal consequences of chronic exposure to primary MPs on larval growth and skeletal development remain largely unknown. Here, we investigated the effects of chronic exposure to PMMA-based glitter MPs (20–50 μm; confirmed by μ-FTIR) on tadpoles of the Neotropical frog Physalaemus signifer, with filter-feeding larvae. Based on previously documented digestive impairment caused by MPs, we hypothesized that PMMA ingestion induces artificial satiety and energetic imbalance, reducing food intake, somatic growth, skeletal development, and ossification. Tadpoles at Gosner stages 30–31 were exposed for 21 days through late larval development and metamorphic progression under three treatments: control, 0.01 g/L PMMA, and 0.1 g/L PMMA. Each treatment consisted of 30 tadpoles distributed across five replicate containers (six individuals each). Skeletal development was assessed through double staining (Alizarin Red and Alcian Blue) and stereomicroscope-based morphometrics of 12 cranial and hindlimb skeletal measurements. Mortality did not differ among treatments ($p > 0.05$), supporting the hypothesis that MPs act primarily as chronic sublethal stressors rather than acute lethal agents. However, Linear Mixed Models revealed severe developmental impairment. Both PMMA concentrations similarly reduced growth by 27–37% and final body mass by 14–21% relative to controls ($p < 0.01$), indicating a strong dose-independent threshold effect. PERMANOVA analyses showed that MP exposure explained 73.1% of total skeletal morphometric variation ($R^2 = 0.731$; $p = 0.004$). Exposed tadpoles exhibited generalized reductions across all 12 skeletal measurements and retained larger cartilaginous areas, indicating delayed osteogenesis and impaired skeletal ossification. Chronic ingestion of PMMA-based glitter MPs induced substantial developmental and skeletal alterations at both concentrations tested. These dose-independent developmental delays may compromise successful metamorphosis in Neotropical amphibians. Our findings provide one of the first assessments of MP-induced disruption of skeletal ossification in amphibians, highlighting osteogenesis as a sensitive and underexplored endpoint in MP ecotoxicology.

Disclaimer/Disclosure: This study was supported by the Federal University of Southern Bahia (UFSB). Luana O. Drummond was supported by a PIBIC undergraduate research fellowship.

2.10.P-We106 Mucus Proteomics in Minnows From Nearby Creeks To Determine the Impact of Aqueous Film Forming Foam (AFFF) Usage at Three Southern Ontario Airports

Cristina Henriques[1], Theresa Warriner[2] and Denina Simmons[1] (1)OntarioTech University, (2)OntarioTechUniversity

Perfluoroalkyl substances (PFAS) are a category of synthetic molecules with many industrial and commercial applications. Common uses of PFAS include non-stick cookware, water resistant adhesives, aviation hydraulic fluids, and aqueous film forming foams (AFFF's). AFFF's are a class of firefighting foams containing many PFAS analogues. The surfactant nature of PFAS allows the foams to extinguish chemical fires, thus making PFAS containing AFFF's useful in industrial zones such as airports. Therefore, it is unsurprising that airport runoff is a significant source of PFAS contamination, especially immediately following AFFF usage. This study aims to determine the health of wild minnows downstream of airports that used AFFFs, by conducting non-targeted proteomics on their epidermal mucus. Epidermal mucus sampling is a non-lethal, non-invasive technique that provides insight into several physiological mechanisms within fish. Proteomic analysis of epidermal mucus reveals information on immune system response, neurological impacts, and cell cycle dynamics. Therefore, by sampling wild fish upstream and downstream of AFFF impacted sites, we aim to determine the in-situ impacts of PFAS on wild-fish. Mucus samples were obtained from four different minnow species, both upstream and downstream of three airports within the greater Toronto area to determine site-specific impacts. Field sampling occurred during the summer months (June-August) for three years (2024-2026). Mucus samples were flash frozen on site and stored at -80oC until sample processing. Samples were analyzed on an Agilent 6545 LC -Q-TOF using non-targeted data-dependent acquisition. Water samples were also collected and analyzed using the same LC-Q-TOF with data-dependent acquisition and Agilent Fluoromatch to determine the profile of PFAS contamination within each site. Up to three years (minimum two) of mucus proteome results and water chemistry data will be presented.

2.10.P-We107 Fish Embryo Monitoring Systems for In-Situ Observation of Early Development in Wild Salmonids

Jeffrey Morris[1], Benjamin Barst[2], Curry Cunningham[3], George Schisler[4] and Mathilakath Vijayan[2] (1)Biodiversity Research Institute (BRI), (2)University of Calgary, (3)University of Alaska Fairbanks, (4)Colorado Parks and Wildlife

almon are a foundational species, playing critical ecological and cultural roles in freshwater and marine ecosystems. A major goal of current research is to determine how developing wild salmon in the freshwater environment are affected by environmental stressors such as elevated water temperatures and contaminants. Salmon embryos develop over many months in gravel nests (redds), a period during which embryos and larvae are sensitive to chemicals and other environmental stressors. Studying development during this critical window is best accomplished in situ, yet live monitoring of embryo development within natural spawning habitats remains technically challenging. We are developing a field-deployable, self-contained Fish Embryo Monitoring System (FEMS) that remotely collects images of salmon embryos during early development and monitors the ambient incubation temperature. Currently, we are validating FEMS performance in the laboratory using rainbow trout (Oncorhynchus mykiss) and kokanee salmon (Oncorhynchus nerka) embryos. We are also evaluating FEMS in the field using sockeye salmon (O. nerka) at Iliamna Lake, Alaska, and adjacent habitats.

We will present temperature and developmental data from fertilization to hatching for both lab and field evaluations. This early developmental data will allow us to fine-tune modeling developmental timing in the context of accumulated thermal units (ATUs) and define ATU-based developmental milestones for unique populations of wild fish. Also, FEMS can be used to improve current ATU estimates of developmental milestones that are important to other predictive models, including adverse outcome pathways leading to developmental disruptions.

2.10.P-We108 Maternal Transfer of per- and Polyfluoroalkyl Substances (PFAS) Mixtures in Great Lakes Rainbow Trout: Early Life Stage Toxicity and Oxidative Stress

Amy Rand[1] and Caitlyn Hsiung[1] (1)Carleton University

Per- and polyfluoroalkyl substances (PFAS) are synthetic fluorinated organic compounds with numerous applications. Due to their widespread use and strong carbon–fluorine bonds, they are resistant to degradation and persist in ecosystems. Higher trophic-level organisms, including fish, are particularly vulnerable to PFAS exposure. PFAS can bioaccumulate and biotransform in fish tissues, altering growth, metabolism, and reproduction. Our previous research has demonstrated that PFAS can be transferred maternally to embryos of salmonid species, suggesting that exposure occurs before hatching and may impair early development and survival. Since environmental contaminants rarely occur in isolation, assessing PFAS mixtures is critical for elucidating realistic ecological impacts. Therefore, this study assesses the effects of maternally transferred PFAS mixtures on the early life stages of Rainbow Trout (Oncorhynchus mykiss), a native North American species found across Canada. To simulate maternal transfer, unfertilized rainbow trout eggs were used, incubated with a mixture of six PFAS—PFHxS, PFHxA, PFOS, PFOA, PFNA, and PFDA—ranging from 0.156 to 156 ppm in Cortland's solution to mimic ovarian fluid, and subsequently fertilized with pooled male sperm. Embryo samples were collected at various timepoints after fertilization (0 h, 12 h, 24 h, 48 h, 1 week, 2 weeks, 4 weeks, post-hatch) and are currently being assessed for superoxide dismutase (SOD) activity, reduced (GSH) and oxidized (GSSG) glutathione ratios, and malondialdehyde (MDA) levels as markers of oxidative stress. We will compare these biochemical markers to two biological viability endpoints: hatching percentages and survival rates, to determine if early-onset oxidative stress is a driver for developmental failure and mortality in PFAS-exposed embryos. We hypothesize that increased exposure to PFAS mixtures will lead to increased SOD activity and MDA levels, lower GSH:GSSG ratios, and hatching and survival rates. The proposed study aims to elucidate the molecular mechanisms driving PFAS accumulation and toxicity during early fish development. Understanding the effects of PFAS mixtures on fish embryos and juveniles will generate ecotoxicological data to inform risk assessments that protect Great Lakes fish species and ecosystems, which provide significant economic and cultural value to Canada.

2.10.P-We109 Comparative Toxicity Profiles of Fipronil and Fipronil Sulfone Revealed by Developmental, Behavioral, and Monoamine-Related Endpoints in Zebrafish

Akira Kubota[1], Chaobao Chen[1], Mei Yamamoto[2], Kyoko Ogura[2], Rumi Tanoue[2], Kei Nomiyama[2] and Yusuke Kawai[1] (1)Department of Veterinary Medicine, Obihiro University of Agriculture and Veterinary Medicine, (2)Center for Marine Environmental Studies, Ehime University

Fipronil is a widely used phenylpyrazole insecticide in agricultural and urban pest control, and its major metabolite, fipronil sulfone, has also been detected in aquatic environments. Both compounds act as antagonists

of γ-aminobutyric acid receptors and are recognized as neuroactive contaminants. Although developmental toxicity and behavioral effects of these compounds have been reported in zebrafish, comparative information on the effects of fipronil and fipronil sulfone remains limited. Therefore, this study aimed to compare the toxicity profiles of fipronil and fipronil sulfone in zebrafish.
Morphological abnormalities, circulatory endpoints, locomotor behavior, sensorimotor responses, and monoamine-related compounds were evaluated following either continuous developmental exposure (4-120 hpf) or short-term exposure at 120 hpf.
Both compounds induced developmental abnormalities, circulatory impairments, and reduced locomotor activity following continuous developmental exposure. These behavioral effects were observed at concentrations that did not cause swim bladder inflation failure, suggesting that locomotor impairment may occur independently of overt developmental toxicity. Fipronil sulfone caused higher mortality than fipronil, resulting in 50% mortality at 1 μM, whereas no mortality was observed in fipronil-exposed embryos at the same concentration. Both compounds caused complete mortality at concentrations of 10 μM and above.
Differences between the parent compound and metabolite became more evident under short-term exposure. Fipronil sulfone induced transient hyperactivity followed by a marked decline in locomotor activity, whereas behavioral effects of fipronil were limited. Monoamine-related compounds showed exposure duration-dependent response patterns. Continuous developmental exposure produced broadly similar monoaminergic responses in both compounds, whereas differences became more evident under short-term exposure, with significant alterations observed only in fipronil sulfone.
These findings demonstrate that integrating behavioral and monoamine-related endpoints can reveal biological responses that are not apparent from conventional developmental toxicity assessments alone. This study highlights the value of incorporating neurochemical indicators into developmental toxicity assessments.

Disclaimer/Disclosure: This work was supported by JSPS KAKENHI Grant Numbers 19H04275 and 22H03746.

2.10.P-We110 Chronic Exposure to β-N-Methylamino-L-Alanine (BMAA) Induces Cognitive Dysfunction in Zebrafish (Danio rerio)

Jinnath Rehana Ritu[1], MD HELAL UDDIN[1], Francisco Carlos da Silva[1], Theodore Oates[1], Maud C.O. Ferrari[1] and Douglas P. Chivers[1] (1)University of Saskatchewan

Cognition refers to the processes by which animals acquire, process, retain, and act on information, encompassing perception, learning, memory, and decision-making. Recognition memory is the capacity to recognize previously encountered objects, events, or places, enabling aquatic organisms to distinguish between familiar and novel stimuli and thereby influencing survival and fitness. Among various environmental neurotoxins, β-N-Methylamino-L-alanine (BMAA) is a neurotoxic amino acid produced by cyanobacteria, diatoms, and dinoflagellates, and its prevalence has emerged as a global environmental problem. The recent concern about this neurotoxin is whether it affects learning and memory, as such impairments can negatively impact biological fitness. However, research on BMAA neurotoxicity on aquatic species remains inadequately characterized. To address this knowledge gap, zebrafish (Danio rerio) embryos were exposed to three environmentally relevant concentrations of BMAA (10, 20, and 40 μg/L), and a control, from 4 hours to 28 days post-fertilization. Subsequently, recognition memory was assessed using a novel object recognition test, and transcriptomic profiling was conducted to identify dose-dependent changes in molecular pathways. The

findings demonstrate that higher BMAA concentrations impair recognition memory in zebrafish and disrupt multiple molecular pathways, including those involved in excitatory signalling, mitochondrial function, oxidative stress regulation, and neuroinflammatory responses. Elucidating the mechanisms underlying BMAA-induced chronic neurotoxicity in aquatic organisms is essential for enhancing ecological risk assessments and informing regulatory standards to safeguard aquatic ecosystems and public health.

Disclaimer/Disclosure: This work was funded by NSERC Discovery Grants awarded to Maud C.O. Ferrari and Douglas P. Chivers. Jinnath Rehana Ritu was supported by a Vanier Canada Graduate Scholarship from NSERC.

2.10.P-We111 Behavioral Screening of Fathead Minnow Larvae To Inform Efficient Experimental Design

Nora Mosch[1], Adam Biales[1] and David Bencic[1] (1)U.S. Environmental Protection Agency (US EPA)

Omics-based approaches are increasingly being used to assess chemical effects. In practice, there is a need to determine if a meaningful biological response is present before committing resources to more costly downstream analyses such as transcriptomics. Behavioral assays can serve as both a cost-effective preliminary step for future transcriptomic studies as well as an apical endpoint to which molecular responses can be related.

A behavioral screening framework was designed for preliminary detection of chemical effects. Behavioral endpoints of fathead minnow larvae were captured with the ViewPoint Zebrabox using photoperiod cycling as a stimulus. These metrics, including activity duration, movement intensity and light-dark responses, were integrated into a standardized Behavioral Deviation Index (BDI), quantifying deviation from control conditions. Dose-response relationships were modeled to estimate effective concentrations (EC10, EC50, EC90), and chemical ranking was defined using the area under the BDI concentration curve generating an effect-based classification system to support decision-making for further transcriptomic testing.

The framework was evaluated across three case studies: (1) an in-house legacy dataset using 13 chemicals generated for omics-based experiments to establish baseline detection, (2) cross-dataset comparison with overlapping chemicals to assess reproducibility of detected effects, and (3) reduced experimental designs to evaluate performance under limited concentrations and replicates. Subsampling analyses demonstrated that behavioral deviation signals were moderately stable under reduced conditions, while cross-dataset comparisons indicated consistent identification of effect presence and relative potency. This framework provides a robust screening layer that is beneficial for identifying chemicals and concentrations that exhibit meaningful behavioral deviation.

Disclaimer/Disclosure: The contents of this abstract neither constitute, nor necessarily reflect, US EPA policy.

2.10.P-We112 Transcriptomic and Behavioral Impacts of Sublethal Azoxystrobin Exposure on Fathead Minnow Larvae

Nora Mosch[1], Morgan Hu[1], Olivia Torano[1], Adam Biales[1] and David Bencic[1] (1)U.S. Environmental Protection Agency (US EPA)

Strobilurin fungicides account for roughly a quarter of the global commercial fungicide market. Azoxystrobin is frequently detected in streams and agricultural sites. Strobilurins act on cytochrome bc1 inhibiting the mitochondrial electron transport chain and ATP synthesis. While several studies have looked at targeted gene transcription, very few studies have established whole transcriptomic profiles of fish exposed to strobilurins and only a handful have ever examined behavior. This study aimed to assess the transcriptomic and behavioral impacts of azoxystrobin on fathead minnow (Pimephales promelas) larvae through a differential gene expression profile and evaluating swimming behavior changes in response to sublethal exposure.

Behavioral results showed a decrease in average total swimming distance in larvae exposed to 10, 20, 40, 80 µg/L under light conditions and in those exposed to 20, 40, and 160 µg/L in the dark. Inactive swimming was significantly higher among larvae exposed to concentrations between 20 and 160 µg/L in both photoperiods, while small-distance activity decreased at similar exposure levels across both light and dark conditions. Notably, large swimming distances increased in larvae exposed to 320 µg/L in both light and dark periods.

Differential gene expression revealed a dose-dependent increase in significantly expressed genes, from 12 genes at the lowest concentration to 3064 at the highest. Gene ontology (GO) analysis identified enrichment in biological processes related to cardiovascular, nervous, and muscular systems, along with molecular functions including enzyme, receptor, and transporter activities. However, no specific GO term was common across all treatment groups.

The findings demonstrate that sublethal azoxystrobin exposure affects both molecular and behavioral endpoints in fathead minnows, possibly through the disruption of energy metabolism. The transcriptomic changes linked to cardiovascular and neuromuscular systems suggest a mechanistic linkage to the observed swimming alterations. Exposure concentrations with noted molecular and behavioral responses are consistent with USEPA's OPP's aquatic life benchmark value used in the environmental assessment of azoxystrobin indicating that new approach methods may yield similar points of departure as those used in traditional testing paradigms.

Disclaimer/Disclosure: The contents of this abstract neither constitute, nor necessarily reflect US EPA policy.

2.10.P-We113 Microplastic Particle Size and Contaminant Co-Exposure Drive Organ-Specific Toxicity in Danio rerio

Renata Fracacio Francisco[1], Paulo Donato Frighetto[2], Pedro Zanrré Magalhães[3], Kelly Cristina de Jesus Silva[4], Ana Clara Azevedo Ivamoto[3], Roger Ivan Valderrama Londono[5], Cleoni dos Santos Carvalho[6] and Lino Félix Morales Paredes[7] (1)UNESP, (2)IFSP _Sertãozinho, (3)UNESP - ICTS, (4)UNESP ICTS, (5)UdeA - Medellín, (6)UFSCAR - Campus Sorocaba, (7)Universidad Nacional de San Agustín de Arequipa

Microplastics are emerging contaminants of increasing concern in freshwater ecosystems due to their persistence, bioavailability, and interactions with other pollutants. However, uncertainties remain regarding the

influence of particle size on tissue distribution and toxicity, as well as the effects of microplastics under multi-contaminant exposure scenarios.

This study investigated the ecotoxicological effects of polyethylene terephthalate (PET) microplastics in adult zebrafish (Danio rerio) using histopathological biomarkers. Chronic 21-day exposure experiments evaluated PET fragments across different particle-size ranges and environmentally relevant concentrations, PET alone and combined with cadmium, and PET-associated exposure scenarios involving organic contaminants. Histological analyses were conducted in gills, liver, intestine, and female gonads.

Particle size strongly influenced toxicological responses. Larger PET particles produced more severe branchial damage, including vascular alterations, lamellar reduction, and lamellar fusion, indicating predominantly mechanical effects on respiratory tissues. In contrast, smaller particles showed greater potential for internalization and systemic distribution, resulting in intestinal and hepatic alterations such as cellular hypertrophy, cytoplasmic vacuolization, increased melanomacrophage centers, and pyknotic nuclei. These findings indicate enhanced bioavailability of smaller particles and greater interaction with internal organs.

Contaminant mixtures further modified toxicity patterns. While PET and cadmium individually induced histopathological alterations, combined exposure produced more pronounced reproductive effects, including changes in oocyte development and increased occurrence of post-ovulatory follicles, suggesting potential impacts on reproductive fitness. Responses were consistently organ-specific and dependent on both particle characteristics and contaminant interactions.

Overall, the results demonstrate that the ecological risks of PET microplastics are determined not only by their presence but also by particle size and co-occurring contaminants. The findings provide new evidence that tissue distribution, organ-specific toxicity, and mixture effects are key drivers of microplastic hazard and should be incorporated into freshwater ecological risk assessment frameworks.

Disclaimer/Disclosure: This research was supported by the São Paulo Research Foundation (FAPESP), Grants No. 2024/06037-8

2.10.P-We114 Assessing Locomotor Behavior, Viability, and Bioaccumulation of the Amphipod Hyallela Azteca in Contaminated Upper Potomac River Sediments

Garrett Driscoll[1], Tyler Frankel[1] and Leanna Giancarlo[1] (1)University of Mary Washington

Trace metal contamination is a widespread environmental concern due to its natural and anthropogenic sources and its known carcinogenic, teratogenic, and reproductive effects. Metal-enriched sediments can negatively affect organismal, population, and ecosystem health, and previous studies have reported elevated metal contamination in portions of the Potomac and Anacostia Rivers. However, metal toxicity from in situ sediments has not been well assessed in benthic aquatic organisms. Most previous studies examining trace metal effects on aquatic invertebrates have relied on laboratory-spiked sediments, while comparatively fewer have evaluated sublethal behavioral effects using field-collected sediments. Therefore, this study assessed the effects of metal-contaminated sediments from multiple shoreline sites along the Upper Potomac River on survival and locomotor behavior in the benthic invertebrate Hyalella azteca. Sediments were collected from 16 sites along

the Upper Potomac River shoreline. Individual 100 mL acid-washed glass jars were prepared with 35 g of dried sediment from each site and inundated with 50 mL of synthetic freshwater. Individual H. azteca were exposed for 9 days at 21°C under static-renewal conditions, with 100% water replacement every 3 days. Organisms were fed 25 µL of a 1:1 diatom and fish flake solution after each water change, and mortality was recorded every 3 days. After 9 days, surviving individuals were transferred to a custom behavioral chamber and recorded for 3 min. Noldus EthoVision XT 17 was used to quantify distance travelled (cm), velocity (cm/min), acceleration (cm/min2), meander (deg/min), and mobility (%). Following exposure, whole tissues were dried, digested, and analyzed by ICP-OES to assess metal bioaccumulation (Ag, Al, As, B, Ba, Bi, Ca, Cd, Co, Cr, Cu, Fe, Ga, K, Li, Mg, Mn, Na, Ni, Pb, Sr, Tl, Zn). Although this study is ongoing, we expect sediments with higher trace metal concentrations to produce greater adverse effects on H. azteca survival and locomotor behavior. We also expect increased sediment metal concentrations to correspond with greater tissue bioaccumulation and disrupted movement patterns. These findings will improve understanding of how sediment-associated trace metals affect benthic invertebrates and help clarify the ecological relevance of locomotor behavioral endpoints in sediment toxicity studies.

2.10.P-We115 Bioavailability and Toxicity of Nickel Ore Concentrate Particles in Arctic Benthic Organisms

Benjamin Paquet[1], Camille Brice[1], Anne Cremazy[1], Richard Saint-Louis[2] and Tamzin Blewett[3] (1)National Institute for Scientific Research (INRS), (2)Université du Québec à Rimouski (UQAR), (3)University of Alberta

Coastal ecosystems are particularly vulnerable to metal contamination resulting from human activities, such as mining. These pressures are expected to intensify in the Arctic due to the growing demand for critical minerals. Among the potential sources of contamination, ore concentrates (enriched products derived from the processing of raw ore may be released into the environment during transport and handling operations. These particles, which often contain metals in addition to the target metal, can accumulate in coastal sediments and affect local wildlife. While the environmental risks associated with dissolved metals have been widely investigated, the bioavailability and toxicity of particulate ore concentrate remain poorly understood, particularly in Arctic coastal ecosystems. This study aims to address this knowledge gap by assessing the bioavailability and toxicity of a nickel concentrate in benthic organisms exposed to contaminated sediments. Clean sediments collected from the Gulf of Saint Lawrence were spiked with environmentally relevant concentrations of nickel concentrate and thoroughly characterized. Toxicity tests are being conducted on Arctic benthic species to evaluate effects on survival and oxidative stress biomarkers (e.g., SOD activity). This work will contribute to improving environmental risk assessments of ore concentrate releases in northern coastal environments.

2.10.P-We116 Effects of Diet Quality on Copper Toxicity in the Freshwater Snail Lymnaea stagnalis

Sara Pouyande[1], Mariem Fadhlaoui[1], Osianna Williams[2], Antoine Faure[3], Léna Guimard[3], Isabelle Lavoie[1] and Anne Cremazy[1] (1)National Institute for Scientific Research (INRS), (2)Université d'Ottawa, (3)Institut National de la Recherche Scientifique

The great pond snail Lymnaea stagnalis is an abundant freshwater pulmonate snail widely used in metal ecotoxicology and environmental risk assessment due to its high sensitivity to metals, particularly copper (Cu). Despite its importance as a model organism, the effects of dietary conditions on juvenile growth and Cu

sensitivity remains poorly understood. Differences in diet quality may influence growth rate and Cu sensitivity, potentially contributing to variability among toxicity studies. This study evaluated the effects of diet quality on growth and Cu sensitivity in juvenile L. stagnalis. In a preliminary experiment, we found that 28-day median effect concentration (EC50) values were 19.0 and 25.2 µg/L Cu, for growth inhibition and mortality respectively. In a second experiment, snails were exposed to control and a sublethal Cu concentration (15 µg/L) under four dietary treatments: lettuce, sweet potato, fish flakes, and lab-grown periphyton. Growth, reproduction, and fatty acid profiles were evaluated. Copper exposure significantly reduced growth only in snails fed sweet potato, and this effect was transient. Diet had a much stronger effect on growth than Cu exposure: snails fed fish flakes exhibited the highest growth rates, followed by lettuce and sweet potato, while periphyton-fed snails displayed the lowest growth. The poor growth of snails fed with periphyton was later found to be due to its high Cu content. Fatty acid analyses showed that snails fed fish flakes contained higher levels of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which can be directly assimilated without metabolic conversion from precursor fatty acids. In contrast, snails fed lettuce and sweet potato likely relied on the limited conversion of shorter-chain fatty acids, which may contribute to lower growth performance. These results demonstrate that diet quality strongly influences juvenile growth and can affect apparent Cu sensitivity in L. stagnalis. Food quality may therefore affect the outcome and interpretation of metal toxicity tests, highlighting the importance of standardized dietary conditions in ecotoxicological protocols. These findings can help optimize culture and testing conditions for L. stagnalis in metal toxicity experiments. Ongoing work will characterize natural diet regimes of wild Québec populations using stable isotope and fatty acid analyses and compare these profiles with laboratory-cultured snails.

Disclaimer/Disclosure: This work was supported by the International Copper Association.

2.10.P-We117 Comparative Toxicity of Short Chain Perfluoroalkyl Sulfonic Acids (PFSAs) and Perfluoroalkyl Carboxylic Acids (PFCAs) During the Embryonic Development of the Freshwater Snail Planorbella pilsbryi

Kallie Shires[1], David McNabney[2], Adrienne Bartlett[2], Amila De Silva[2], Stacey Robinson[2] and Ève Gilroy[1]
(1)Environment and Climate Change Canada, (2)Environment and Climate Change Canada (ECCC)

Short chain perfluoroalkyl acids (PFAAs) are environmentally persistent and widely distributed contaminants that pose an increasing risk to ecosystem and wildlife health. Early developmental stages may be particularly vulnerable to these compounds due to heightened sensitivity and limited physiological defenses. In this study, we evaluated the effects of perfluoroalkyl sulfonic (PFSA) and carboxylic (PFCA) acids on the embryonic development of the freshwater snail Planorbella pilsbryi using a 21-day chronic toxicity assay. Endpoints included developmental progression, proportion of deformities, time to hatch, and hatching success. The 21-day EC_{50} values for hatching ranged from 94 mg/L (PFOS) to 6653 mg/L (PFBA), demonstrating that toxicity varied with fluorinated carbon chain length and functional group.

Because PFAAs occur as complex mixtures in the environment, we further assessed mixture toxicity using EC_{50}-derived toxic units. Two binary mixtures were examined: PFOA–PFOS (C8 carboxylate and sulfonate) and PFHxS–PFOS (C6–C8 sulfonates). Each mixture was tested across 13 concentrations spanning environmentally relevant levels to 2 total toxic units in a 21-day assay. The PFOA–PFOS mixture exhibited effects consistent with a concentration addition model, suggesting a shared mode of action. In contrast, the PFHxS–PFOS mixture showed variable responses and merits further investigation. These findings highlight the

importance of considering mixture effects and chemical structure when assessing the ecological risks of PFAAs.

2.10.P-We118 Vector Effects of Polystyrene Microplastics As Carriers of 2,4, 6-Tribromophenol on Sea Urchin Pluteus Larvae

Kazuki Kaneseki[1], Mizuki Matsumoto[1], Hiroshi Fujisaki[2], Katsuhisa Eguchi[2], Yuki Takai[3], Yohei Shimasaki[3], Takashi Inoue[4], Koji Yoshitake[4], Yuusuke Ueda[4] and Yuji Oshima[3] (1)Kyushu University, Fukuoka, Japan, (2)Saga Prefectural Genkai Fisheries Research and Development Center, Karatsu, Saga, Japan, (3)Kyushu University, (4)Carbon Neutral Society Promotion Division, Saga Prefectural Government, Japan

Background: Microplastic (MP) pollution from degraded expanded polystyrene (EPS) is an increasing concern in coastal environments. In Japanese waters, urchin barrens, which are widespread seaweed bed collapses, are a serious ecological issue. Sea urchin overgrazing drives barrens; however, the mechanisms underlying persistent overabundance in food-depleted environments remain unclear. Seaweed-derived allelochemicals, such as 2,4,6-tribromophenol (TBP), inhibit larval settlement and regulate populations. MPs adsorb hydrophobic organic compounds from water and transport them to organisms—the "vector effect." We hypothesized that EPS-derived polystyrene MPs (PS-MPs) exert a vector effect on TBP by adsorbing it from seawater, reducing its bioavailability, and attenuating its settlement-inhibitory activity, thereby promoting larval settlement and contributing to barren formation.
Methods: Experiment 1: Magnetite-embedded PS-MPs (5 mg/L) were incubated for 24 h in TBP solutions (1 and 10 mg/L). MPs were retrieved using a magnet, and the adsorbed TBP was quantified using LC-MS after ethanol elution. Experiment 2: 8-arm pluteus larvae of Hemicentrotus pulcherrimus were exposed to TBP (20 mg/L) alone or co-exposed to PS-MP (1, 5, or 10 mg/L; n = 3, ~20–30 larvae/well). Survival was monitored at 0, 12, 24, 48, 60, and 72 h. Kaplan-Meier curves were compared using log-rank tests.
Results: Experiment 1: PS-MPs adsorbed TBP at both concentrations, with greater adsorption at higher concentrations; negligible TBP was detected in the controls. Experiment 2: Larval survival differed significantly among the groups. Co-exposure to TBP + PS-MP significantly improved survival compared to TBP alone at all PS-MP concentrations, indicating that PS-MPs reduced effective TBP exposure.
Conclusions: PS-MPs adsorbed TBP from seawater, reducing its bioavailability and attenuating larval toxicity. As TBP also inhibits settlement at sublethal concentrations, reduced bioavailability may similarly attenuate allelochemical regulation of settlement. This suggests that MP contamination disrupts allelochemical-mediated regulation of urchin settlement, potentially contributing to overabundance and barren formation. These findings provide experimental support for a link between MP pollution and coastal degradation, with implications for fishery management and conservation.

2.10.P-We119 Environmental Occurrence and Biological Interactions of Microplastics in the Eastern Oyster (Crassostrea virginica)

Lady Volmar Claudio[1], Sue Ebanks[1] and Paul Pennington[2] (1)Savannah State University, (2)National Oceanic and Atmospheric Administration (NOAA)

Microplastics, plastic particles ranging from 0.1 μm to 5 mm, are increasingly recognized as emerging contaminants in estuarine ecosystems due to their persistence, widespread distribution, and availability to aquatic organisms. These particles originate from primary sources, including textiles and personal care products, as well as secondary sources resulting from the breakdown of larger plastic debris. The small

dimensions of microplastic make them readily available for ingestion by filter feeders, including oysters, potentially affecting feeding, reproduction, development, and overall physiological function. Because oysters provide important ecological and economic services within estuarine systems, understanding their interactions with microplastics is important for both ecosystem and seafood health assessments. This research examines the environmental occurrence and biological interactions of microplastic in the Eastern oyster, Crassostrea virginica, within Country Club Creek and adjacent waterways connected to the Herb River in Savannah, Georgia. Monthly water sampling and seasonal sediment and oyster collections are being conducted to evaluate microplastic occurrence across sites, reef elevations, and environmental conditions. In addition to environmental monitoring, a controlled microcosm exposure study was conducted through a collaborative internship with NOAA to explore oyster interactions with red acrylic microfibers under simulated tidal conditions over a 14-day exposure period. Preliminary observations confirmed successful microfiber introduction and persistence within treatment systems throughout the exposure period. Samples collected from field surveys and experimental systems are currently undergoing laboratory processing and analysis, including particle isolation, characterization, and quantification. Ongoing analyses evaluate microplastic occurrence within water, sediment, and oyster tissues while assessing potential exposure and accumulation pathways under both field and experimental conditions. This research will establish baseline information on microplastic occurrence in a southeastern salt marsh system and improve understanding of oyster-microplastic interactions, contributing to ongoing efforts to support seafood safety, ecosystem health, and inform coastal management decisions.

Disclaimer/Disclosure: This project is funded by the National Oceanic and Atmospheric Administration, Office of Education Educational Partnership Program award (NA21SEC4810005) and the NSF Excellence in Research award (2301650).

2.10.P-We120 Development of an Ecotoxicity Assessment Approach for Degradation Products of Long-Life Biodegradable Plastics

Norihisa Tatarazako[1] and Yukiyo Okazaki[1] (1)Ehime University

Biodegradable plastics are expected to reduce environmental burdens associated with conventional plastics; however, the ecological effects of their degradation products remain poorly understood. Intact polymer materials generally have limited bioavailability because of their large molecular size and restricted cellular uptake. In contrast, degradation in the environment can generate lower-molecular-weight products that may become more bioavailable and potentially pose ecological risks. Therefore, environmental risk assessment should consider not only the parent polymer but also degradation products.

Despite this concern, current regulatory frameworks provide limited guidance for the ecotoxicological assessment of stable polymeric materials. Existing test methods were primarily developed for soluble chemicals and are not always suitable for evaluating long-life biodegradable plastics designed to maintain durability during use.

This ongoing study aims to develop an ecotoxicity assessment approach for degradation products of long-life biodegradable plastics being developed under a NEDO project. These materials are designed to remain functional for more than 10 years, making accelerated degradation necessary to obtain environmentally relevant

degradation products within a practical timeframe. Currently, UVC irradiation and thermal hydrolysis are being investigated as pretreatment methods to generate partially degraded materials. Following optimization of degradation conditions, aquatic toxicity tests using Daphnia and fish will be conducted to evaluate potential toxicity associated with degradation.

The outcomes of this study are expected to provide a scientific basis for the environmental safety assessment of long-life biodegradable plastics and contribute to the development of future testing and regulatory frameworks for biodegradable polymer materials.

Disclaimer/Disclosure: This study was supported by the New Energy and Industrial Technology Development Organization (NEDO), Japan.

The authors declare no competing financial interests and no conflicts of interest related to this work.

2.10.P-We121 Impacts of Resuspension of Sediment-Associated Contaminants in Daphnia magna

Hailee Richesin[1], Cristina La[1], Shawn Acuna[2] and Michael Lydy[3] (1)Southern Illinois University Carbondale, (2)Metropolitan Water District of Southern California (MWD), (3)Southern Illinois University

The Sacramento Deep Water Shipping Channel (SDWSC) is a dynamic aquatic environment characterized by large quantities of fine suspended solids (<62.5µm), which are subject to resuspension as vessels pass through this vital maritime connection. It is not well understood how this resuspension affects the uptake of suspended solid-bound hydrophobic organic contaminants (HOCs) in pelagic zooplankton. Additionally, critically endangered Delta smelt (Hypomesus transpacificus) are known to inhabit the SDWSC, raising concern regarding their exposure to suspended solid-bound HOCs while feeding on zooplankton amongst plumes of resuspended sediment. This study examines the potential uptake of hexachlorobiphenyl (HCBP), in common pelagic zooplankton prey species D. magna. Treatments included three particle size fractions (15-32µm, 32-45µm, and 45-63µm) spiked with spiked with 14C-HCBP. For each particle size fraction, experimental chambers receiving no inversion of suspended solids were compared to test chambers receiving three daily inversions, simulating the resuspension that occurs with ship passing within the SDWSC. Results of the uptake studies showed that the HCBP accumulated rapidly in the D. magna and the uptake was dependent upon the sediment particle size. Resuspension of the spiked suspended solids through the inversion of the test chambers increased the uptake in the D. magna. These results should allow for a better understanding of how sediment resuspension effects bioaccumulation in pelagic prey species and allow for more informed management decisions concerning risk to pelagic species within the SDWSC.

2.10.P-We122 A Trans-Generational Benthic Warning of Oxidative Stress Induced by Short-Chain Chlorinated Paraffins in Chironomus riparius

Chi-Ying Hsieh[1], Shao-Yang Hu[2], Jhih-Jyun Dong[1] and Meng-Chun Wu[1] (1)Department of Environmental Engineering and Science, National Pingtung University of Science and Technology, Pingtung, Taiwan., (2)Department of Biological Science and Technology, National Pingtung University of Science and Technology, Pingtung, Taiwan.

Short-chain chlorinated paraffins (SCCPs) are persistent organic pollutants in aquatic ecosystems, yet their trans-generational biochemical effects on benthic invertebrates at environmentally relevant concentrations remain poorly understood. This study examined oxidative stress and detoxification responses in the benthic midge Chironomus riparius exposed to SCCPs from F0 to F2 generations through aqueous and algae-mediated dietary pathways. Nine scenarios combined blank, average, and maximum SCCP concentrations in water with dietary exposure. Based on 46 Taiwanese river water samples collected during wet and dry seasons, the average and maximum concentrations were 0.337 and 0.757 μg/L, associated with industrial wastewater. SOD, CAT, GPx, and GST were the biomarkers that were examined. The results showed generation-specific and exposure-route-dependent responses. SOD showed early but transient induction, reaching 0.3251 U/mg protein in F1 under combined aqueous average and dietary maximum exposure, but declining to 0.0016 U/mg protein in F2 under the same condition. This indicates a shift from initial radical-scavenging activation to suppression or exhaustion after transgenerational exposure. In contrast, CAT activity increased across generations, through aqueous exposure, rising from 15.94 U/mg protein in the F0 control to 35.09–36.83 U/mg protein in F2 aqueous maximum groups. GPx showed the most consistent increase, with mean activity rising from 41.21 in F0 and 47.01 in F1 to 65.41 nmol NADPH oxidised/min/mg protein in F2 ($p < 0.001$). In F2, GPx activity was 65.4% higher under aqueous maximum exposure and 49.5% higher under dietary maximum exposure than in the corresponding controls, indicating sustained activation of peroxide- and lipid peroxide-scavenging pathways. GST increased markedly in F1, with 161.4% and 2.13-fold increases under maximum aqueous and dietary exposure, respectively, but decreased significantly in F2, suggesting that detoxification capacity may not be maintained under prolonged stress.

Disclaimer/Disclosure: This study was supported by the National Science and Technology Council, Taiwan, under grant number NSTC 114-2221-E-020-007-MY3. The authors declare no conflict of interest.

2.10.P-We123 PFAS and PAH Effects in a Petroleum Spill Impacted Stream in Anderson County, SC

Peter Van den Hurk[1] (1)Clemson University

The Broadway Creek watershed in Anderson County SC has been impacted by a large underground spill of diesel and gasoline as a result of a broken transport pipeline in 2014. Contaminated groundwater is still flowing downhill from the spill site and emerges in the upper reaches of Broadway Creek. While the pollution is monitored at the spill site by SC Department of Environmental Services, no water quality monitoring is performed further downstream. A Citizen Science project was initiated in 2025 to fill this knowledge gap, and started measuring basic water quality parameters at regular locations between the spill site and Broadway Lake. In addition to standard measurements like temperature, dissolved oxygen and pH, passive samplers were used to get an impression of the polynuclear aromatic hydrocarbon (PAH) distribution in the watershed. To get an idea

of possible PFAS contamination, water samples were monitored for 55 PFAS chemicals in 2026.
The results for 2025 showed that the water quality is considerably different at the spill site compared to downstream sites and nearby reference sites. Especially dissolved oxygen was lower at this site, but also pH and conductivity. The lower oxygen levels at the spill site may be related to higher microbial activity responsible for breakdown of the petroleum products. The deployed passive samplers showed consistent high levels of two-ring PAHs at the spill site, with lower levels further downstream. For 3- and 4-ring PAHs the maximum levels are in the middle of the watershed; these pollutants are more likely related to stormwater runoff from roads. Surprisingly, a reference location close to the petroleum spill site showed relatively high PFAS concentrations, especially for PFBS. Additionally, fecal coliform bacteria were measured, which were very low at the spill site, and higher further downstream, but still below state water quality norms. In 2026 we also started to collect crayfish as bioindicators for water quality, and included nutrients analysis to get an expanded overview of water quality in the watershed.

2.10.P-We124 An Overview of the Process in Creating Site-Specific Water Quality Conditions for an Industrial Facility

Michael Jirsa[1] (1)EA

The development of site-specific water quality criteria for individual metals through the performance of biological translators or water effect ratio studies has successfully enabled permittees to modify the National Pollutant Discharge Elimination System (NPDES) discharge permit single metal permit limits. This testing concept is based on the U.S. Environmental Protection Agency (EPA's) recognition that the metals can be substantially less toxic in an effluent/receiving water matrix than in clean laboratory water, on which the single metal permit limits are often based. Additionally, the ratio of dissolved to total fractions of the metal can greatly affect the toxicity of the specific metal. One metal in particular that has commonly been evaluated through these studies is copper. The toxicity of copper is dependent on site-specific factors such as pH, hardness, total suspended solids and dissolved organic carbon. This presentation outlines the process used to develop site-specific copper criteria for an industrial facility that discharges non-contact blowdown cooling water.
Key steps in the project included conducting a chemical translator study, performing whole effluent toxicity (WET) testing, and implementing Toxicity Identification Evaluation (TIE) procedures. Through TIE testing, EA identified multiple potential toxicants including polar organics, non-polar organics, and oxidants as contributors to observed toxicity. Further investigation, in collaboration with the client, traced the sources of these toxicants to water conditioning chemicals used for controlling corrosion, biological growth, and scaling in the cooling system.
As a next step, EA is working with the facility to optimize the dosage of these treatment chemicals relative to the flow rate of the blowdown water. The ultimate goal is to bring the facility into consistent compliance with its NPDES permit and to support successful modification of the copper discharge limits.

2.10.P-We125 Toxicity and Modeling of Contaminants of Emerging Concern for Prioritization

Emma Michael[1], Ruth Harper (Sofield)[1] and Christopher James[2] (1)Western Washington University, (2)University of Washington

Contaminants of Emerging Concern (CECs) are chemicals for which toxicological, occurrence, and regulatory

information remain limited. As the detection of CECs in the environment continues to increase, there is a need to understand their potential impacts to inform future environmental regulations and management strategies. However, the number of CECs identified in the environment far exceeds the pace at which they can be thoroughly studied, underscoring the importance of utilizing all information available including New Approach Methodologies, to better assess their potential for causing environmental harm.

To aid in the prioritization of CECs detected in Puget Sound, this project aims to apply existing frameworks for comparison. Under Objective one, the stepwise prioritization framework developed by Maloney et al. (2025) will be applied, using chemistry data from James et al. (2023) to prioritize CECs based on their potential for causing biological impacts. The resulting prioritization will be compared to results reported by James et al. (2023) to understand differences and identify potential gaps in chemical categorization.

Objective two involves the development and application of a hybrid prioritization framework designed to address gaps identified through Objective one. This hybrid framework will integrate the James et al. (2023) framework with components from Maloney et al. (2025), including environmental fate and transport. The additional components may enhance the original James et al. (2023) framework and result in an updated prioritization for Puget Sound.

Mercury in Fish in a Changing World: Trends, Drivers and Effective Risk Assessment and Management

2.12.P-We182 Mercury in the Salmon and Snake Rivers, Idaho-Oregon-Washington, USA

Austin Baldwin[1], Collin Eagles-Smith[1], James Willacker[1] and Sarah Janssen[1] (1)U.S. Geological Survey (USGS)

Methylmercury (MeHg) concentrations in sturgeon and some other fish species in the lower Snake River (Idaho-Oregon-Washington, USA) approach or exceed Idaho's safe consumption criterion of 0.3 mg/kg, presenting a human health risk to members of the Nez Perce Tribe and other frequent consumers. Sources of MeHg to the lower Snake River and the drivers of its bioaccumulation are only partially understood; a major information gap includes the Hg contributions from the Snake River's largest tributary, the Salmon River. Draining mountainous central Idaho, the Salmon River is treasured for its wilderness, boating, and subsistence and recreational fishing, which are culturally and economically important to the region. The current study sought to improve understanding of Hg and MeHg sources, concentrations, and bioaccumulation in the Salmon River Basin and its contributions to the lower Snake River. We sampled Hg and MeHg in water, sediment, and fish at up to 40 locations throughout the basin and across a range of hydrologic conditions and seasons between May 2023 and July 2024. Concentrations of inorganic Hg (IHg) and MeHg were generally greater in the Salmon River and its tributaries compared to the Snake River, with apparent seasonal MeHg production in the Salmon River during summer months. Fish tissue Hg concentrations were also greater in the Salmon River, exceeding the consumption criterion in 67% of largescale suckers, 86% of smallmouth bass, and 100% of white sturgeon. However, trout and mountain whitefish in Salmon River headwaters did not exceed the consumption criterion, even downstream of a historic Hg mine where IHg concentrations reached 729 ng/L, suggesting the IHg was not bioavailable within that reach. Given the wild nature, lack of impoundments, and relatively steep

gradients in the Salmon River Basin, our results raise new questions about the processes driving Hg methylation and bioaccumulation within the watershed, and underscore the potential health risks posed by frequent consumption of some fish species.

Disclaimer/Disclosure: Funding and support for this study were provided by the Nez Perce Tribe, Idaho Power Company, and the U.S. Geological Survey.

2.12.P-We183 Exploring Terrestrial-Aquatic Links of Mercury Mobilization and Accumulation in Subsistence Fish of Weenusk First Nation Homeland

Haley MacLeod[1], Adam Kirkwood[2], Sam Hunter[3], Brian Branfireun[4], Erik Emilson[5], Mary-Claire Buell[1] and Constance O'Connor[2] (1)Trent University, (2)Wildlife Conservation Society (WCS) Canada, (3)Weenusk First Nation, (4)Western University, (5)Natural Resources Canada

Weenusk First Nation, located in the northern Hudson Bay Lowland (HBL), has expressed concerns around how climate change is affecting their Homeland and their food sovereignty. The HBL is the world's second-largest peatland complex, contains North America's lowest latitude continuous permafrost, and supports significant biodiversity and numerous Indigenous communities' relationships with the lands and waters in the region. The Homeland of Weenusk First Nation supports healthy fish populations, allowing community members to readily harvest and eat fish. However, this area is experiencing rapid warming, and members of Weenusk First Nation have expressed concerns about the risk of thawing permafrost on water quality and harmful contaminants, including methylmercury. Methylmercury is a toxic form of mercury known to bioaccumulate in fish, and recent work has shown that permafrost thaw may increase the mobilization of mercury into freshwater ecosystems. Working with community Knowledge Holders and Youth, we identified two tributaries that drain from large peatland complexes and flow into the Winisk River around important fish harvest sites. At these locations, we collected peat core, water samples, and fish tissue samples from community harvested fish for mercury analyses, which are complemented by long-term (1977-2025) subsistence fish species mercury and size data from across the Winisk River. Existing fish contaminant consumption guidelines in this region are based on sparse data and do not consider community consumption patterns, or the food sovereignty of Weenusk First Nation. This work is co-created with Weenusk First Nation and explores terrestrial-aquatic links of mercury mobilization, considers the role of climate change in altering these dynamics, establishes environmental contaminant baselines, and supports the development of culturally relevant fish consumption guidelines. Weenusk First Nation lies downstream of proposed development sites for the Ring of Fire mining area raising additional concerns for further contaminant exposure in the future. The outcomes of this project can act as a framework for other communities in the region experiencing similar climate change and development impacts. Overall, this work will support Weenusk First Nation's food sovereignty, climate change resilience, and decision making around future development, including mineral development, in their Homelands.

2.12.P-We184 Past, Long-Term Methylmercury Exposure From Freshwater Fish Consumption Predicts Current Blood Mercury Levels in Grassy Narrows First Nation

Jennifer Lee[1], Aline Philibert[1], Myriam Fillion[2], Judy Da Silva[3] and Donna Mergler[1] (1)UQAM, (2)TELUQ, (3)Grassy Narrows First Nation Mercury Justice Team

Background: Long-term methylmercury (MeHg) exposure through the long-term consumption of fish is pharmacokinetically different than one-shot, occasional, or short-term exposure. Many Toxicological Reference Values (TRVs) derive from a blood total mercury (THg) half-life estimate of 50 days. However, multi-compartment models suggest that elimination may depend on background levels, raising the possibility that Hg is continuously remobilized from long-term tissue stores into the blood.

Objective: We investigated the relationship between past, long-term Hg exposure from freshwater fish consumption, elimination dynamics, and current blood THg levels in Grassy Narrows First Nation.

Method: As part of a community-university research partnership, we analyzed 16,452 single-centimeter hair THg measures from 634 individuals between 1970-1997. Annual post-peak half-lives were fitted in a subset of 185 individuals and regressed on age, sex, and sampling year. Analyses of variance (ANOVA) were used to investigate the relationship between reported current fish consumption and blood THg. For 35 individuals with ≥ 40 measurements, Longitudinal Mixed-Effect Models (LMEM) investigated associations between past hair and current blood THg measurements (2021-2022).

Results: Past Hg exposure followed clear annual patterns of fish consumption, with late-summer peaks preceding wintertime decay. Estimated seasonal half-lives (median = 103.3 days; IQR [76.4; 147.5]) lengthened over the 28-year sampling period ($\beta = 2.33$, $p = 0.0003$). Current blood THg (median = 2.6 µg/L; [0.6; 9.6]) reflected current fish consumption ($F(2,32)= 7.43$, $p = 0.002$) but remained positively associated with historic hair THg measures after adjusting for current fish consumption ($\beta = 0.086–0.22$ across models, $p < 0.001$).

Conclusion: In the context of freshwater fish consumption, our findings suggest that current blood THg concentrations reflect both recent exposure and long-term body burden, with possible implications for public health guidelines in communities with long-term exposure. TRVs may underestimate Hg burden in populations with long-term historic exposure due to elevated background levels, the remobilization of Hg from long-term tissue stores, and overall slower rates of elimination.

2.12.P-We185 Linking Sources to Levels of Mercury in Water and Fish of the Mackenzie River Under Future Climate Scenarios

Una Jermilova[1], Holger Hintelmann[1] and Jane Kirk[2] (1)Trent University, (2)Environment and Climate Change Canada

Arctic climate change is intensifying pathways of mercury release to freshwater ecosystems, including in the Mackenzie River system of Canada’s Northwest Territories. We developed a Bayesian Network Relative Risk Model (BN-RRM) to assess how mercury sources may be affecting mercury levels in surface water and five fish species. Sources considered in the model included atmospheric deposition, soil erosion, permafrost thaw, and proximity to thaw slumps and fossil fuel development.

The model was updated to incorporate projected changes in rainfall erosivity (R-factor) and permafrost thaw under three CMIP6 (Coupled Model Intercomparison Project Phase 6) climate scenarios: SSP1-2.6, SSP2-4.5, and SSP5-8.5. Across all scenarios, R-factors are projected to increase, with mountainous regions showing increases of up to ~22% by 2100 under the moderate-emissions SSP2-4.5 scenario. Mercury release from permafrost thaw is projected to increase in the near term, followed by a decline by 2100 under SSP5-8.5 as shallow active-layer mercury stores become depleted. This result highlights uncertainty in long-term projections because deeper permafrost mercury stores are not yet represented in the model.

We also incorporated 543 freshwater samples and 24 fish samples newly available since the previous model version. These additions changed predicted regional water mercury concentrations by -8% – +73% and decreased northern pike mercury concentrations by ~17%, although new fish data were only available for the southernmost region. Fish mercury concentrations were mainly influenced by fish size, thaw slump proximity, and permafrost thaw. The average predicted changes in levels of mercury across all five fish species by mid-century under the three climate scenarios modelled ranged from -4.1% – +2.4 %. Our analysis highlights key drivers of mercury accumulation and amplification under climate change, shaping changes in mercury levels in water and fish in a northern freshwater river system. The BN-RRM framework is now being adapted for community-scale application in the western Canadian Arctic by combining mercury monitoring with local knowledge systems to support tracking, understanding, and stewardship of freshwater resources under a changing climate.

2.12.P-We186 How Much Fish Can I Safely Eat? – A Novel Mobile App That Provides Personalized Fish Consumption Guidance Accounting for Cumulative Exposure to Methylmercury From Wild-Caught and Retail Fish

Norm Healey[1] and Gary Mann[1] (1)Azimuth Consulting Group Inc.

Fish are an important source of nutrition and provide important cultural, social, economic, and environmental benefits. Increasing access to sustainably harvested fish is widely recognized as a strategy to improve food security, reduce health disparities, support Indigenous food sovereignty, and lower the environmental footprint of food systems. However, fish are also the primary source of human exposure to methylmercury, a developmental neurotoxin. Emerging evidence suggests that climate-driven changes in aquatic ecosystems may increase methylmercury concentrations in some fish populations, making it increasingly important to balance the risks and benefits of fish consumption.

Traditional fish consumption advisories typically provide generalized recommendations based on individual fish species and often focus on limiting consumption to reduce methylmercury exposure. Research has shown that these approaches can unintentionally discourage fish consumption, reducing nutritional benefits and adversely affecting cultural, social, and environmental values. These consequences disproportionately affect populations that rely heavily on fish for nutrition, cultural value, and food security.
To address these challenges, we developed a novel mobile app that provides personalized and holistic fish consumption guidance. The app generates individualized recommendations based on user-specific characteristics that influence methylmercury exposure and susceptibility, including age, body weight, and pregnancy status. The app also accounts for cumulative methylmercury exposure from any combination of wild-

caught and retail fish species for which mercury data are available.

This presentation will include a demonstration of the app to illustrate how personalized, holistic decision-support tools can improve mercury risk assessment and communication. For example, rather than simply counselling users to reduce fish consumption, the app helps users maintain or increase fish consumption while managing their exposure to methylmercury by facilitating the substitution of lower-mercury fish for higher-mercury fish, thus reducing exposure to methylmercury while preserving the benefits of fish consumption.

As climate change, food security, health disparities, and Indigenous reconciliation increasingly intersect with mercury management, tools that help people make informed fish consumption choices while maintaining the benefits of fish consumption are increasingly important.

2.12.P-We187 Mercury and Selenium Concentrations, Selenium:Mercury Molar Ratios, and Selenium Health Benefit Values in Billfishes From the Northwestern Gulf of Mexico

Joseph Kuntz[1], Kristyn Armitage[1], Benjamin Barst[2], Brian Jackson[3], Kesley Gibson-Banks[4], Gregory Stunz[4] and Jessica Dutton[1] (1)Texas State University, (2)University of Calgary, (3)Dartmouth College, (4)Harte Research Institute

Mercury (Hg) is a toxic, nonessential trace element that is well-known to bioaccumulate in fishes and biomagnify in marine food webs, so long-lived top predators such as billfishes (e.g., marlins, swordfish, sailfish) have the greatest tissue concentrations. Selenium (Se), an essential trace element, has an antagonistic relationship with Hg, forming a Hg-Se complex that is toxicologically inert. Currently, fish advisories regarding Hg exposure are issued based on the Hg concentration in muscle tissue; however, it has been proposed that the Se:Hg molar ratio and Se health benefit value (HBVSe) could be used as additional seafood safety criteria in risk assessment. A Se:Hg molar ratio > 1:1 suggests that Se may have a protective effect against Hg toxicity and a positive HBVSe indicates there may be health benefits from consuming that species, whereas a negative HBVSe value indicates health risks. This study investigated the inter- and intraspecies variability in Hg and Se concentrations, Se:Hg molar ratios, and HBVSes in muscle tissue of Atlantic blue marlin (Makaira nigricans; n = 16), swordfish (Xiphias gladius; n = 12), and sailfish (Istiophorus platypterus; n = 14) caught off the Texas coast in the northwestern Gulf of Mexico. Blue marlin had the greatest mean wet weight Hg and Se concentrations (9.29 and 4.07 µg/g, respectively) and sailfish had the lowest (0.802 and 0.614 µg/g, respectively). 100% of blue marlin, 83.3% of swordfish, and 42.9% of sailfish exceeded the FAO/WHO 1 µg/g Hg advisory level for predatory fishes. Only blue marlin had a positive relationship between Se concentration and Hg concentration. All three species had a mean Se:Hg molar ratio > 1:1, suggesting that Se may have a protective effect against Hg toxicity. However, on an individual-basis, 12.5% of blue marlin and 25% of swordfish had a Se:Hg molar ratio < 1:1, indicating that Se is not protective in all individuals. The mean HBVSe was positive in all species suggesting there are health benefits from consuming these species; however, 12.5% of blue marlin and 25% of swordfish had a negative value, indicating there may be health risks. Swordfish had a negative relationship between Se:Hg molar ratio and body length and HBVSe and body length, whereas blue marlin and sailfish had no relationship. Due to the high Hg concentrations and variable Se:Hg molar ratios and HBVSes, billfishes should not be consumed to minimize exposure to Hg from seafood consumption.

Stormwater Runoff Impacts, Solutions and Innovative Research

2.13.T-01 Tire Derived Chemicals and Pesticides in Time and Space: Insights From a River and Stormwater Ponds

Zihang Wang[1], Andrew Erickson[1] and William Arnold[1] (1)University of Minnesota

Two separate year-long sampling campaigns were undertaken to understand the dynamics of pesticides and tire derived chemicals in the Minneapolis-St. Paul metro area. Weekly samples from the Mississippi River show distinct temporal patterns among contaminant classes. Tire-derived chemicals exhibited pronounced concentration peaks during spring snowmelt, whereas pesticide concentrations were highest in early summer following agricultural application periods. Pesticides showed strong positive correlations with river discharge indicating inputs from increased runoff, while the wastewater indicator metformin was negatively correlated with discharge, consistent with dilution of point-source inputs. For stormwater ponds, multi-pond sampling with drainage-area land use analysis enabled the identification of spatially distinct contaminant fingerprints across the urban landscape, and long-term sampling revealed characteristic temporal dynamics of pesticides and tire-derived contaminants. Overall, stormwater ponds integrate contaminant inputs from both runoff and precipitation and indicate distinct chemical fingerprints associated with different contaminant sources. The tire-derived chemicals were detected with the highest concentrations in the spring, indicating that snowmelt runoff is driving large inputs into the urban aquatic environment in cold-climate areas. Pesticides like atrazine and metolachlor in urban areas were identified with intense precipitation during agricultural application periods, even though they are not locally applied. Both classes of compounds are delivered with rainfall, but the temporal patterns reveal different dynamics and sources. Overall stormwater ponds capture temporally and spatially representative chemical signatures of the surrounding urban area and those transported atmospherically, suggesting that adaptive management to maximize treatment efficiency is needed.

Disclaimer/Disclosure: This work was supported by the Minnesota Environment and Natural Resources Trust Fund.

2.13.T-02 Early-Life Chronic Exposure to 6PPD-Quinone Alters Acute Sensitivity in Coho Salmon (Oncorhynchus kisutch)

Anastasia McConachie[1], Jeffrey Perala-Dewey[2], Melissa Gonzalez[2], Melissa Driessnack[3], Nathan Ivy[3] and Jenifer McIntyre[3] (1)Washington State University (WSU), (2)University of Washington Tacoma, (3)Washington State University

6PPD-quinone (6PPDQ), a transformation product of the tire additive 6PPD, is acutely toxic to coho salmon at low ng/L concentrations, yet little is known about how chronic early-life exposure influences subsequent sensitivity. Here, we examined whether developmental exposure history modifies acute toxicity responses to 6PPDQ in coho salmon alevins and early fry.

Fertilized eggs were generated on site and split evenly into control and treatment groups following acclimation to laboratory conditions. Beginning 8 days post-fertilization, the treatment group received repeated pulsed exposures of 6PPDQ (100 ng/L), administered twice weekly over a 76-day developmental period, while control fish were maintained under identical conditions without chemical exposure. Acute sensitivity was evaluated

using 24-hour mortality following nominal 6PPDQ challenges spanning environmentally relevant to elevated ng/L concentrations. Dose-response relationships were modeled using a two-parameter log-logistic dose-response function with 95% confidence intervals, pooling data from a pilot study and three definitive trials with age- and accumulated thermal unit (ATU)-matched controls.

Across pooled experiments, chronically exposed fish consistently displayed reduced mortality relative to naïve controls at equivalent challenge concentrations, reflected in a rightward shift in the fitted dose-response relationship and higher predicted median effect concentrations (ED50). In parallel, chronically exposed fish exhibited delayed developmental progression, including increased yolk retention relative to controls at matched developmental time points, suggesting that altered sensitivity may occur alongside shifts in developmental state.

These results demonstrate that early-life chronic pulsed exposure to 6PPDQ can alter acute toxicity responses later in development. This work illustrates the importance of developmental context and exposure history in evaluating toxicological risk and suggests that reliance on acute-only toxicity metrics may overlook biologically meaningful shifts in sensitivity under repeated low-level exposure scenarios.

2.13.T-03 The Unique Chemistry and Toxicity of 6PPD/6PPD-Quinone

Hui Peng[1] (1)University of Toronto

6PPD-Quinone was recently identified as a potent toxicant to coho salmon and several other salmonid species. Herein, we demonstrate that the phenylenediamine and tertiary carbon moieties of 6PPD/6PPD-quinone lead to their unique chemistry and toxicity. 1) Structurally selective toxicity to salmonids was observed for 6PPD-quinone, but not other PPD-Q analogues with similar structures. 2) Hydroxylation of the alkyl side chain catalyzed by CYP450 enzymes was observed for 6PPD-Quinone but not for other PPD-Quinone analogues, primarily due to the weak C–H bond at the C4 tertiary carbon. 3) The phenylenediamine moiety of 6PPD confers a high oxidation potential and promotes rapid formation of the 6QDI oxidation product, which motivated the development of a rapid testing kit. The unique chemistry and toxicity of 6PPD/6PPD-quinone can be leveraged for a broad range of research, including safer antioxidant design and molecular toxicology studies.

2.13.T-04 Urban Stormwater Runoff as a Pathway for Established and Emerging per- and Polyfluoroalkyl Substances (PFAS) to Receiving Waters

Rebecca Sutton[1], Ezra Miller[1], Kelly Moran[2], Miguel Mendez[1], Alicia Gilbreath[1], Kayli Paterson[1], Jennifer Dougherty[1], Richard Grace[3] and Diana Lin[1] (1)San Francisco Estuary Institute, (2)No Affiliation, (3)SGS AXYS

An urban estuary that supports a population of over 7 million people, San Francisco Bay (California, USA) serves as a useful laboratory for studies of anthropogenic contaminants in urban stormwater and impacts on receiving waters. The majority of the region is served by separate storm drain systems, which channel stormwater flows directly to the Bay without treatment. On behalf of the Regional Monitoring Program (RMP) for Water Quality in San Francisco Bay, in 2018 we began development of a robust stormwater monitoring effort to characterize PFAS concentrations and build a dataset for estimating loads to the Bay. Our work has demonstrated that well-studied PFAS, such as perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA), are commonly observed in urban stormwater in the Bay Area, with measured concentrations rivaling those in effluents from the region's municipal wastewater treatment plants. In addition to firefighting foams and

metal-plating mist suppressants, PFAS sources particularly relevant to outdoor urban environments include outdoor paints and coatings, roofing materials, textiles, solar panels, artificial turf, and automotive products. Currently, stormwater samples are analyzed for the 40 PFAS listed in EPA Method 1633 via liquid chromatography coupled to tandem mass spectrometry (LC-MS/MS), with subsets of samples subjected to more extensive targeted analysis of analytes such as ultra-short chain compounds, fluorotelomer alcohols (FTOHs), polyfluoroalkyl phosphate diesters (diPAPs), bis(trifluoromethanesulfonyl)imide (TFSI), and the total oxidizable precursors (TOP) assay to measure unknown precursors. We are also piloting collection and analysis of PFAS in precipitation to explore the contribution of this pathway to stormwater and the Bay. PFAS sources, transformation, and transport processes will need more detailed studies to inform management of this complex pollutant class. Results to date emphasize the role of urban stormwater runoff in PFAS transport to surface waters.

2.13.T-05 Early-Life Stage Toxicity of 6PPD-Q and 6PPD-Q Metabolites in Fathead Minnow (Pimephales promelas) and Rainbow Trout (Oncorhynchus mykiss)

Catherine Roberts[1], Blake Hunnie[1], Juleanne Flores[1], Parker Jones[1], Julie Borsa[2], Jenna Donkin[2], Janel Wessel[2], Aleksandra Dovichak[2], Markus Hecker[1] and Markus Brinkmann[1] (1)University of Saskatchewan, (2)Toxicology Centre, University of Saskatchewan, Saskatoon, SK, Canada

Recently, N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine-quinone (6PPD-Q), a derivative of the rubber tire antiozonant 6PPD, was identified as the causative agent of Urban Runoff Mortality Syndrome, wherein some coho salmon populations returning to freshwater suffer acute mortality prior to spawn. Since its identification, 6PPD-Q has been the focus of intense research into the toxicity associated with various aquatic species (coho salmon LC50 0.095 □g/L; Arctic char LC50 >12.7 µg/L). Notably, 6PPD-Q toxicity among salmonids, even those that are closely related, can vary widely. This discrepancy in sensitivity may be associated with toxicokinetic factors. Both the production of a toxic metabolite, or the species-specific clearance of 6PPD-Q itself, have been suggested as potential drivers of sensitivity. To better understand the role of metabolism in this toxicity profile, an early-life stage toxicity tests were performed on rainbow trout (Oncorhynchus mykiss; RBT) alevins, and fathead minnow embryos (Pimephales promelas; FHM), representing sensitive and insensitive species, respectively. Alevins and embryos were exposed to 6PPD-Q and two hydroxylated 6PPD-Q metabolites (para-OH and alkyl-OH), to determine if a greater toxicity was observed with a potentially toxic metabolite. FHM embryos were exposed at <32-cell stage for 144 hours, RBT alevins were exposed at hatch for 12 days, both with a 70% daily renewal. Concentrations of 6PPD-Q and its metabolites ranged from 0.25-64 µg/L (FHM) and 0.125-4 µg/L (RBT), with the inclusion of solvent (0.01% dimethyl sulfoxide) and water control. Embryos and alevins were observed daily for mortality and morphological changes, and flash frozen upon termination for future xenometabolome analysis. Analysis of mortality found no significant difference across any treatments of 6PPD-Q or 6PPD-Q metabolites in FHM. RBT alevins exhibited decreased sensitivity to 6PPD-Q as compared to previous studies, with a 12-day LC50 of 4.72 µg/L. Interestingly, the LC50 for 6PPD-Q para-OH was similar to that of 6PPD-Q, at 4.84 µg/L, while the 6PPD-Q alkyl-OH did not elicit significant mortality in RBT alevins.

2.13.T-06 River Floodplains As Plastic Sinks To Prevent Ocean Plastic Pollution: The Role of Riparian Vegetation and Biodiversity for Plastic Retention

Arne Cierjacks[1], Pauline Seidel[1], Xhoen Gjashta[1], Sabrina Selinger[1], Danilo Schneider[1], Marjol Meco[2], Sajmir Beqiraj[2] and Kathrin Harre[1] (1)Hochschule für Technik und Wirtschaft Dresden - University of Applied Sciences, (2)University of Tirana

Rivers are major contributors to global marine plastic pollution and, therefore, a key intervention point for reducing environmental microplastic load. Intact fluvial ecosystems may retain a significant amount of transported plastic particles along with co-pollutants in floodplains soils and vegetation. Owing to the complexity of riparian ecosystems, the assessment of the role of rivers for plastic retention remains inherently difficult. Moreover, most river systems are anthropogenically altered with clearly reduced retention potential. Here, we present data of macro- and microplastic pollution from two contrasting European river systems: The heavily modified Elbe river in Germany and the Vjosa in Albania, one of the last naturally flowing rivers in Europe. To our knowledge, these are the first studies to asses plastic pollution across entire river systems under varying hydrological conditions and quantifying plastic loads on a mass base using DSC and TED-GC/MS. Both river systems proved to retain significant amounts plastic particles, with hydrological regime, riparian vegetation and proximity to urban areas as the principal drivers of plastic retention magnitude. For the Vjosa our data demonstrate that the majority of macroplastics mobilized during major flood events was intercepted by riparian vegetation and thus never reached the Mediterranean sea. We further developed and experimentally tested nature-based retention modules as a targeted intervention for highly altered river courses where natural retention capacity was lost. Using standardized reference particles, retention efficiency varied markedly among plant species and with plastic composition, which points to the role of biodiversity for efficient plastic retention in river systems. Retention of microplastic particles through vegetation reached up to 91.4% of the particles transported by the water course per module. Overall, addressing river floodplains and their retention services represents a scalable intervention to reduce environmental microplastics and prevent ocean pollution. Further research is needed to optimize plastic retention and to understand the conditions governing remobilization to downstream and marine environments.

Disclaimer/Disclosure: This study was funded by Deutsche Forschungsgemeinschaft (DFG), Grant nr. 533323188 and 558546608

Stormwater Runoff Impacts, Solutions and Innovative Research

2.13.P-Th238 In Situ Field Assessment of the Toxicity of 6PPD-Quinone in Juvenile Coho Salmon (Oncorhynchus kisutch) in Urban Stream Water During Stormflow

Mason D. King[1], Gary Yang[1], Carys Gallilee[1], Angela Duso[2], Kevin Soulsbury[1], Peter S. Ross[3] and Tanya M. Brown[1] (1)Simon Fraser University, (2)British Columbia Institute of Technology, (3)Raincoast Conservation Foundation

Coho salmon (Oncorhynchus kisutch) are an ecologically and commercially important species in North America, and have a special significance to Indigenous communities along the Pacific coast and its streams. However, many urban streams that serve as spawning and rearing habitats for coho regularly receive rainfall-

induced urban runoff carrying potentially harmful mixtures of polycyclic aromatic hydrocarbons (PAHs), metals, road salt, and tire-associated contaminants. Recently, 6PPD-quinone (N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine-quinone), a transformation product of the tire rubber antioxidant 6PPD, was implicated as the primary causal contaminant causing recurrent die-offs of coho salmon in Washington State. Subsequent stream monitoring indicates that hazard is widespread in urban salmon habitat. The mechanisms underlying the toxicity of 6PPD-quinone to coho salmon are not yet fully understood. We investigated the effects of urban runoff on juvenile coho salmon at a river in Metro Vancouver, British Columbia (Canada) during stormflow conditions by characterizing road runoff contaminants and acute lethality, and applying high-throughput multi-omics approaches. Hatchery populations of juvenile coho salmon in streamside aquaria were exposed to a continuous flow of water pumped directly from the stream immediately after the onset of rain (N = 86), recirculating river water collected during baseflow conditions (N = 87), and baseflow river water spiked with 6PPD-quinone used as a positive control (N = 106) for a period of 24-hours. Following the 24-hour exposure periods, surviving coho were anesthetized and euthanized for the collection of tissues for transcriptomic, proteomic and metabolomic assessments. Analyses of water samples revealed variable but generally elevated concentrations of 6PPD-quinone, metals, pesticides and polycyclic aromatic hydrocarbons during stormflow. Peak 6PPD-quinone concentrations during wet weather events reached 158 ng/L, four times higher than recent LC50 effects thresholds for juvenile Oncorhynchus taxa. This presentation will highlight preliminary results on urban runoff exposure effects, with an emphasis on survival and omics endpoints. This project will inform regulatory agencies as they evaluate the toxicity of this chemical.

2.13.P-Th239 A Feasibility Study of Using Surf Smelt Eggs for Biomonitoring Intertidal Spawning Marine Forage Fish Exposure to Contaminants in Storm Water

Norm Healey[1], Chloe Kraemer[2], Jennie Christensen[3], Geriene Labine[3] and Alexandra Wade[3] (1)Azimuth Consulting Group Inc., (2)Peninsula Streams and Shorelines, (3)TrichAnalytics Inc.

Surf Smelt (Hypomesus pretiosus) are marine forage fish that spawn in sand-gravel upper intertidal habitats throughout the Salish Sea. During an incubation period of approximately two to four weeks, Surf Smelt embryos may be susceptible to contaminants discharged from intertidal stormwater outfalls, including metals and polycyclic aromatic hydrocarbons (PAHs). Existing community science programs routinely collect Surf Smelt eggs during spawning habitat surveys to identify and monitor spawning beaches; however, these samples are typically counted and either returned to the habitat or discarded.

From 2020 to 2025, volunteers with Peninsula Streams and Shorelines, a non-governmental organization in the Capital Regional District of British Columbia, collected between 729 and 17,292 Surf Smelt eggs annually from approximately 60 intertidal habitats. In 2025 and 2026, we undertook a pilot study to evaluate the feasibility of repurposing these samples for biomonitoring contaminant exposure in intertidal spawning marine forage fish.

Using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS), we successfully quantified bioaccumulation of metals characteristic of stormwater runoff in samples containing as few as four Surf Smelt eggs. The ability to analyze extremely small mass samples is critical because egg collection is labour intensive and many survey samples contain fewer than 10 eggs (10 Surf Smelt eggs weigh approximately 10 mg wet weight).

This approach may provide several advantages over conventional water or sediment quality monitoring by integrating exposure over time and quantifying contaminants at the biological site of action, thereby accounting for transport and fate in the environment and bioavailability, bioaccumulation, and bioconcentration in the embryo. The ultimate objective of this work is to leverage existing citizen science sampling programs to investigate contaminant exposure risks to intertidal spawning forage fish in urbanized coastal environments.

This pilot study established the feasibility of measuring metal bioaccumulation in small-mass Surf Smelt egg samples. Future work will evaluate the feasibility of quantifying expression of the cyp1a gene, a biomarker of PAH exposure, in similarly small mass samples of Surf Smelt eggs.

2.13.P-Th241 Tire-Wear Compound 6PPD-Quinone Effects on Green Sea Urchin (Strongylocentrotus droebachiensis) Early Development Following Adult Exposure

Davide Asnicar[1], Christine Weiss[2], Tillman Benfey[2] and Danielle Philibert[1] (1)Huntsman Marine Science Center, (2)University of New Brunswick

6PPD-quinone (N-(1,3-dimethylbutyl)-N′-phenyl-p-phenylenediamine-quinone) is a transformation product of 6PPD (N-(1,3-dimethylbutyl)-N’-phenyl-p-phenylenediamine), a chemical commonly used in car tires to prevent rubber degradation, and the culprit for urban runoff mortality syndrome. Approximately 3.1 billion tires are produced each year globally, each with the potential to increase 6PPD-quinone presence in urban streams, receiving waters, and ultimately marine coastal areas. The vast majority of 6PPD-quinone-related work has been centred on fish, with particular focus on sensitive salmonid species and model fish species, leaving a gap of knowledge regarding other marine organisms, including invertebrates. In our recent research, we have been screening several species (including American lobsters, periwinkle snails, lumpfish, Atlantic cod, and three spined stickleback) for sensitivity to 6PPD-quinone. No notable effects have been observed in any of the species, except for the green sea urchin (Strongylocentrotus droebachiensis) embryo development. Based on measured concentrations, the EC50 for pluteus development is 1.3 µg/L for this species. Results from aquatic vertebrates suggest that 6PPD-quinone toxicity is associated with ion dysregulation. Balance of ion fluxes is critical during early developmental stages, particularly in the transition from blastula to gastrula. Efforts are in place to understand the mechanism of toxicity of the chemical in sea urchin and determine the most sensitive embryonic stage. Moreover, studies have been conducted by exposing adults S. droebachiensis to determine if parental exposure can result in impaired pluteus development. After a 24-hr exposure, parental crosses between control and treated organisms were carried out. Results suggest that the compound alters the eggs, whereas the exposure of males did not alter the embryo development. These results expand our knowledge of 6PPD-quinone toxicity in marine invertebrates and help inform road-runoff management practices and tire additive impacts in coastal environments.

2.13.P-Th242 Non-PPD Alternatives for 6PPD: An In Vivo and In Vitro Assessment

William Hart-Cooper[1], Justin Greer[2], Michelle Hladik[2], Ellie Dalsky[2], Paxton Bachand[2], Malik Al-Afyouni[3], Anh Tran[1], Colleen McMahan[1] and John Hansen[2] (1)US Department of Agriculture-ARS, (2)U.S. Geological Survey (USGS), (3)Flexsys, Akron, OH.

6PPD quinone (6PPDQ), formed from the tire antidegradant 6PPD, is a principal driver of Urban Runoff Mortality Syndrome, triggering acute mortality of coho salmon and other salmonids in waters adjacent to high

traffic corridors. To reduce ecological risk while maintaining tire safety performance, viable replacements for 6PPD must be evaluated across environmental and engineering criteria. In coordination with California's Safer Consumer Products activities, we assessed four non PPD antidegradant candidates. Candidates were prioritized based on laboratory screening for ozone protection performance in solution and in model tire compounds—lab prepared rubber formulations that emulate production tire tread—and were then advanced to toxicity screeningTo enable direct comparison with 6PPD/6PPDQ, we implemented a solution phase ozonation protocol calibrated with 6PPD and verified by liquid chromatography-high resolution mass spectrometry (LC-HRMS) to reflect environmentally relevant exposure that yield concentrations of 6PPDQ that would be toxic for coho salmon. We then applied standardized, severity matched conditions to each candidate so that transformation profiles and hazards could be compared. Both parent compounds and ozonation products were tested across 10 mg/L down to 1 µg/L (nominal exposure concentrations) using established cytotoxicity and metabolic assays in salmonid cell lines derived from coho salmon, Chinook, and rainbow trout. Complementary in vivo exposures were conducted with juvenile coho salmon and coastal cutthroat trout, species identified as highly sensitive to 6PPDQ. To contextualize hazard relative to antidegradant function, we also quantified oxygen scavenging capacity via solution viscometry under the same controlled ozonation regime. Initial results indicate that some candidates exhibit lower aquatic hazard signals while maintaining antioxidant behavior, supporting continued development of non PPD antidegradants that balance aquatic protection with tire performance requirements.

2.13.P-Th243 Assessing the Potential Toxicity of Non-PPD Antidegradants on Salmon: Alternative Solutions for the 6PPD Dilemma

Justin Greer[1], Malik Al-Afyouni[2], Michelle Hladik[1], Ellie Dalsky[1], Paxton Bachand[1], Elisabeth LaBarbera[1], Corey Sanders[1] and John Hansen[1] (1)U.S. Geological Survey (USGS), (2)Flexsys America L.P., Akron, OH.

6PPDQ, a transformation product of the tire antidegradant 6PPD, has been linked to Urban Runoff Mortality Syndrome, causing sudden mortality of coho salmon and other salmonids in waters near busy roadways. To mitigate these impacts while maintaining tire safety performance, less toxic alternatives to 6PPD are urgently needed. Under California's Safer Consumer Products regulation, tires containing 6PPD have been prioritized for an ongoing Alternatives Assessment, accelerating research across the community and industry. We conducted tire relevant performance screening of >350 non PPD candidates. Two candidates were then selected for addressing potential toxicity using in vitro and in vivo approaches. We developed a solution based ozonation assay, calibrated with 6PPD and verified by liquid chromatography- high resolution mass spectrometry (LC–MS) to emulate environmentally relevant exposure conditions that yield 6PPD quinone at concentrations associated with coho salmon toxicity; we then applied the identical ozonation settings to candidate 6PPD alternatives to enable like for like comparison of transformation products and potential hazards. Parent compounds and their solution ozonated forms were evaluated across 1 µg/L to 2 mg/L (stock concentrations LC MS verified) using established cytotoxicity and metabolic assays for salmonid cell lines (Chinook, steelhead, rainbow trout, and coho). Complementary in vivo assessments for coho salmon were performed using 6-week post hatch swim up fry; a sensitive developmental stage for 6PPDQ mediated toxicity. We will present comparative toxicity across Pacific salmon cell lines and coho salmon fry. Initial findings indicate that some candidates warrant further development as promising 6PPD alternatives, balancing environmental protection with critical tire performance requirements.

2.13.P-Th244 Biochar-Amended Stormwater Filtration for Simultaneous Removal of E. coli and Contaminants of Emerging Concern (CECs): A Case Study at Agate Bay

Stephanie Eytcheson[1], Johanna Jernberg[2], Tadele Haile[1] and Bridget Ulrich[1] (1)Natural Resources Research Institute (NRRI), (2)University of Minnesota Duluth

Exposure to contaminated recreational waters poses a risk of illness; thus, swimming beaches are monitored for E. coli and are closed when concentrations exceed allowable limits. Urban stormwater runoff is a source of E. coli and organic contaminants of emerging concern (CECs; e.g., pesticides, flame retardants, pollutants from vehicles). While previous research has typically focused on treatment approaches to address individual contaminants or classes of contaminants, the composition of stormwater may require multiple treatment approaches for simultaneous contaminant removal. Previous studies suggest that both E. coli and organic contaminants, both susceptible to passing through conventional biofilters, interact with biochar via hydrophobic interactions and may be removed simultaneously using a single treatment approach. Thus, the purpose of this study is to determine whether biochar-amended field-scale systems are effective for mitigating E. coli and organic CECs. Agate Bay (Two Harbors, MN) was selected as a case study site due to historical exceedances of E. coli. A stormwater treatment train consisting of a two-stage sedimentation ditch followed by a biochar-amended sand biofilter was installed in Agate Bay in Summer 2025. Intermittently dosed column tests were performed in the laboratory to simulate E. coli and organic contaminant removal in a biochar-amended system, and field evaluations are underway to assess performance of the system at field-scale. Laboratory results suggest that organic CEC removal is dependent on selecting appropriate biochar while E. coli removal is dependent on hydraulic conditions. While installation of best management practices (BMPs; e.g., the treatment train at Agate Bay) is typically motivated by federal and state regulations for managing specific contaminants, results from this work indicate that individual BMPs can have multiple benefits, such as simultaneous removal of multiple contaminants. This work will inform BMPs to aid stormwater and water quality managers in selecting media amendments in biofiltration systems.

Disclaimer/Disclosure: This project was supported by the Minnesota Stormwater Research and Technology Transfer Program administered by the University of Minnesota Water Resources Center.

2.13.P-Th245 Treads to Treatment: Converting Tire Waste Into Bioretention Media for Removing Stormwater Pollutants

Koral Griffith[1], Alanna Hildebrandt[2], Jessica Ray[2] and Jenifer McIntyre[1] (1)Washington State University (WSU), (2)University of Washington

Roadway runoff contains contaminants toxic to aquatic organisms. Green stormwater infrastructure (GSI), such as bioretention systems, can reduce these impacts, but compost-based media leach nutrients and don't fully nullify the sublethal effects in salmonids, indicating room for improvement and alternative substrates. Char made by pyrolysis of organic matter is a promising alternative sorbent for bioretention. Char to reduce nutrient leaching. Char from used tires reduce waste. Tire derived char could potentially introduce contaminants to aquatic habitats, undermining GSI goals. Our study will test whether tire derived char impairs a model aquatic organism by leaching toxic chemicals or preventing their sorption in GSI. In preparation for these tests, we conducted two pilot studies to 1) determine the exposure duration to which the developmental and behavioral endpoints would be most sensitive, and 2) the development and validation of a synthetic stormwater mixture.

Zebrafish embryos were exposed to 10 g/L crumb rubber (SBR) leachate in 48-well plates with daily solution renewals and monitoring of survival, hatching, and abnormalities. Morphological imaging and behavioral assays were conducted at 48, 96, and 120 hours post-fertilization (hpf) to assess developmental toxicity. Synthetic stormwater was developed using high resolution mass spectrometry (HRMS) to apportion sources of contaminants to roadway runoff, including tire particles, used motor oil, windshield washer fluid, etc. We measured the resulting chemistry and toxicology to validate that the mixture simulates roadway runoff. Exposure to 10 g/L SBR leachate caused early developmental disruption in zebrafish embryos. Morphological effects, including reduced relative eye area and body length, were more apparent at 96–120 hpf than at 48 hpf. Physiological impairment also increased over time, with greater cardiovascular abnormalities at later stages. Differences between 96 and 120 hpf were not significant, indicating that the 96 hpf was the most optimal for further testing. Results of the synthetic stormwater validation will also be presented.

2.13.P-Th246 Plastic Free Constructed Floating Wetland Scaffolds

Sarah White[1], Ada Camila Montoya[1], Levi J. McKercher[2], Erin M. Barr[1] and William H.J. Strosnider[2]
(1)Clemson University, (2)University of South Carolina, Baruch Marine Field Laboratory

Constructed floating wetlands (CFWs) are a green infrastructure strategy used to improve water quality in stormwater ponds. Most commercially available CFW systems rely on plastic-based materials, such as high-density polyethylene or polyurethane, to achieve buoyancy and long-term durability. While effective, these plastic components can degrade over time and potentially contribute to microplastic pollution. This project used a two-pronged approach to address this limitation by developing CFW scaffolds that are (1) biodegradable or (2) glass-aggregated based. Both scaffold styles were evaluated over several design iterations. The fully biodegradable field scale CFW design was developed through sequential trials from 2019 through 2026 and focused on maximizing durability, buoyancy, and plant growth. The glass-aggregated based “aeroCFW” was evaluated from 2024 to present, focusing on scaffold durability, longevity, and plant growth. The fully biodegradable design ultimately integrated a compression fit wooden frame with whole cork strips, coir fabric, and plant materials. The aeroCFW scaffold integrates ultra-lightweight aero-glass aggregates with steel hardware cloth and plant materials. System performance was assessed by monitoring floating stability, material durability, and plant growth over time. Two (Panicum hemitomon and Typha latifolia) of the five plant species evaluated in the biodegradable CFWs remained buoyant over winter. Two additional (Pontederia cordata and Canna flaccida) plant treatments were refloated with additional bark strips and the CFWs remain buoyant with healthy plants after overwintering in 2026. The aeroCFWs remained buoyant and structurally intact with plants also growing back after overwintering in a stormwater pond. Both scaffold designs are a promising advance for non-plastic based CFW applications.

Disclaimer/Disclosure: This abstract was prepared as a result of work sponsored by the South Carolina Sea Grant Consortium with NOAA and the Department of Commerce financial assistance number NA23OAR4170175

2.13.P-Th247 Climate-Informed Design Storms for Stormwater Contaminant Resilience: Linking Future Extreme Precipitation, Runoff Quality, and Receiving-Water Risk

Minki Hong[1] (1)Exponent

Stormwater runoff management is increasingly challenged by changing precipitation extremes. Traditional stormwater design and risk evaluations often rely on historical intensity-duration-frequency (IDF) curve, such as NOAA Atlas 14, to define design storms, assess flood risk, and evaluate contaminant transport potential. However, observed trends and climate model projections indicate that extreme precipitation is changing in many regions, potentially reducing the reliability of stationarity-based design assumptions. Larger or more frequent high intensity events can alter runoff volumes, erosion potential, and contaminant mobilization. This affects both traditional pollutants such as metals, PFAS, and microplastics.

This presentation describes a climate-informed framework for linking projected extreme precipitation to stormwater contaminant fate, transport, and management decisions. The approach begins with development of projected IDF datasets using downscaled climate projection data, extreme value analysis, nonstationary methods, and uncertainty characterization. These projected design storms can then be translated into hydrologic and hydraulic model inputs to evaluate future runoff, inundation, and thus BMP loading conditions.

The framework is particularly relevant for assessing whether existing BMPs and engineered controls remain protective under future climate conditions. Higher flow rates and altered storm sequencing may reduce hydraulic residence time or mobilize particle-bound contaminants. At contaminated or industrial sites, extreme rainfall and flooding may also remobilize legacy pollutants, alter groundwater gradients, and create new exposure pathways. By integrating climate science and water-chemical coupled modeling, climate-informed stormwater evaluations can support more resilient BMP design by understanding increasing risks that extreme precipitation poses to contaminant mobilization. As a showcase application a PFAS mobilization sensitivity analysis to evaluate how future precipitation changes may influence runoff-driven and infiltration-driven transport will be performed. The analysis will consider varying soil properties, topographic conditions, and initial PFAS concentrations to identify the site characteristics most likely to increase PFAS release and redistribution during extreme storm events.

Technology-Critical Elements: From Sources, Exposure and Effects to Environmental Risk Assessment

2.14.T-01 Amphipods (Hyalella azteca) and Zooplankton As Sentinels of Rare Earth Elements, Uranium and Thorium in a Northern Mining Region Contaminated With Arsenic

Justine Labelle[1], Dominic Ponton[1], Holly Marginson[1], Claude Fortin[2], Maikel Rosabal[3] and Marc Amyot[4] (1)University of Montreal, (2)National Institute for Scientific Research (INRS), (3)University of Quebec in Montreal (UQAM), (4)University of Montreal (UdeM)

Growing demand for green energy and new technologies is driving rare earth elements (REEs) mining. The historically arsenic-contaminated region of Yellowknife (NWT), near the Nechalacho REE mine, presents complex conditions that may influence bioavailability and accumulation of REEs and co-occurring radionuclides (U, Th) in aquatic organisms. We evaluated the amphipod Hyalella azteca and zooplankton as potential biomonitors for REEs, U, Th, and arsenic by sampling ten lakes in the Yellowknife region. Lanthanum

(La) concentrations were among the lowest reported in Canadian fresh waters (0.01–0.07 nmol L^{-1}). In zooplankton, La bioaccumulation was negatively influenced by physicochemical variables (protein-like compounds of dissolved organic matter, pH and phosphate), while U free ion concentrations best predicted U accumulation, and dissolved organic carbon was found to reduce Th accumulation. In H. azteca, La, U, and Th concentrations in littoral sediments strongly predicted bioaccumulation, and U accumulation was likely reduced by carbonate complexation in water. Arsenate (As(V)) in surface water emerged as an important predictor for La, U, and Th amphipod bioaccumulation. Even after EDTA washing, Fe strongly predicted La accumulation, suggesting that their association is not solely due to surface adsorption. As accumulation in both taxa correlated with aqueous As(V) and, in amphipods, also with sediment concentrations. These results were summarized in a conceptual model that illustrates the key processes controlling the bioaccumulation pathways of La, U, Th, and As, providing a framework for assessing environmental risks of REE mining in northern Canada, particularly in arsenic-contaminated regions.

Disclaimer/Disclosure: This research was funded by the Natural Sciences and Engineering Research Council of Canada (NSERC) through the Alliance program (ARCMITE, ALLRP 576112–22) and by Polar Knowledge Canada (POLAR), which provided funding for fieldwork activities.

2.14.T-02 Potential Bias in Metal Internalization Rates Induced by Colloid Formation: The Case of Indium Uptake by a Microalga at pH 7

Ophélie FONTAINE[1], Séverine Le Faucheur[1], Sandra Mounicou[1] and Javier Jimenez Lamana[1] (1)Université de Pau et des Pays de l'Adour, CNRS, IPREM, Pau, France

Indium (In) is a trivalent hard-acid metal increasingly used in electronic technologies, but its interactions with aquatic organisms remain poorly studied. This study aims to better understand In uptake by the model green microalga Chlamydomonas reinhardtii at environmentally relevant pHs. Algae were exposed to dissolved In concentrations ranging from 10^{-9} to 10^{-6} M for 30 min and collected by centrifugation at three different time steps. Algae were then rinsed with ethylenediaminetetraacetic acid, acid-digested and analyzed by inductively coupled plasma mass spectrometry (ICP-MS) to measure their intracellular indium concentrations. Internalization rates were determined from the temporal increase in intracellular indium concentrations. In parallel, dissolved indium concentrations were monitored by filtration of the exposure medium and measurements by ICP-MS.

A large proportion of In was found to precipitate in the exposure media. The results were therefore expressed as a function of the time-weighted dissolved In concentrations. Indium internalization was strongly affected by pH, with rates at 1.8×10^{-19} mol. $cell^{-1}.min^{-1}$ at pH 5 and 1.5×10^{-20} $mol.cell^{-1}.min^{-1}$ at pH 7 at 0.08 µM In exposure. For all tested concentrations, accumulation kinetics displayed a positive intercept rather than passing through the origin. Such behavior is generally attributed to strong adsorption of trivalent metals onto cellular surfaces. However, subcellular fractionation revealed that none of the In was associated with the cell membranes. Rapid In elimination by C. reinhardtii was also excluded. We therefore hypothesized that dissolved In speciation changed during exposure. To test this hypothesis, colloid formation was monitored using Single-Particle ICP-MS. The number of In-containing particles increased throughout the 30 min exposure period at both pHs, with a greater increase at pH 5. This result suggests a decrease in bioavailable dissolved In during exposure. A Michaelis–Menten modelling at pH 7 yielded a maximum internalization flux of 1.78×10^{-20} $mol.cell^{-1}.min^{-1}$ and a half-saturation constant of 7.37×10^{-9} M at pH 7. This maximum flux is about 100 times

lower than values reported for other trivalent metals. This difference is likely due to changes in the speciation of dissolved In, which reduced its bioavailability and biases estimates of internalization rates.

2.14.T-03 Predicting Ecological Responses to Metal Mixtures Using Experimental Stream Ecosystems

Travis Schmidt[1], Christopher A. Mebane[2], Laurie S. Balistieri[2] and Janet L. Miller[3] (1)U.S. Geological Survey (USGS), (2)USGS, (3)BLM

Cobalt (Co), copper (Cu), and nickel (Ni) are essential trace elements to life but can cause toxicity when elevated in freshwater. These elements are important commodities to global technological and energy economies. However, Co and Ni have been declared critical minerals for the economic and national security of the United States (U.S.) due to vulnerabilities in their supply chains. Mineral deposits that contain economically recoverable Co also contain either Ni, or Cu and Ni. To sustain economic and national security, previously unexploited domestic Co deposits are likely to be explored and mined. While Cu and Ni are commonly observed in freshwater ecosystems and have aquatic life standards, no standard exist for Co. To address this knowledge gap, we conducted a 30-day mesocosm experiment exposing naïve benthic invertebrate communities to unary, binary, and ternary mixtures of Co, Cu, and Ni. Effect Concentration causing 50% change (EC50) to total mayfly abundance for each unary exposure series were: 11 ug/L for Cu, 18 ug/L for Co, and 38 ug/L for Ni. In biofilms, metal accumulation suggests that inclusion of Cu in mixtures enhanced accumulation of Co and Ni relative to unary exposures, yet Cu accumulation was unaffected by the inclusion of Co or Ni in metal mixture exposures. In filter feeding caddisflies, metal accumulation generally decreased in metal mixture exposures relative to that observed in unary exposures. We employed the response addition model to determine if metal mixtures elicited effects more/less than expected under the assumption of additivity. In all mixtures, invertebrate community responses measured as total mayflies or Bray-Curtis Similarity, suggest that mixtures cause effects at lower concentrations than unary metal exposures caused. While at higher concentrations metal mixtures cause less toxicity than expected. This suggests mixture complexity leads to unexpected toxicity suggesting that Co can be toxic to aquatic life and that mixtures including Cu and Ni do not follow the standard assumption of additivity in all situations.

2.14.T-04 Linking Metal Chemistry to Subcellular Fate in Various Aquatic Organisms Using Machine Learning QICARs

Cândido Rodrigues[1], Luana Bauer[1], Isabelle Lavoie[2], Claude Fortin[2] and Maikel Rosabal[1] (1)Université du Québec à Montréal, (2)Institut National de la Recherche Scientifique

Ecological risks posed by trace elements remain a critical concern, especially for technologically critical elements (TCEs) lacking toxicological data and regulation. Because metal toxicity is linked to intracellular distribution, subcellular behaviour of TCEs may be predicted using metal chemical descriptors. Here, we developed quantitative species-specific ion character–activity relationship (QICAR) models to predict metal subcellular compartmentalization in sensitive (mitochondria, microsomes and lysosomes, cytosolic heat-denatured proteins) and detoxified compartments (granules, cytosolic heat-stable proteins). Our dataset included measurements of 29 trace elements across nine fish species, one amphipod, and one mammal, collected from mining-impacted sites, together with 19 metal descriptors covering physical, electronic, binding, and redox properties. Models were developed using log10-concentrations (nmol/g) and machine learning based on tree-

based categorical boosting. Predicted subcellular concentrations were summed across all fractions and converted into percentages to estimate subcellular metal distribution. Models were validated using leave-one-species-out and 10-fold cross-validation, on the pooled dataset and species-specific groups (fish, amphipod, and mammal). Covalent index, ionic index, and atomic weight were the best-fitting chemical descriptors selected by stepwise AIC, indicating that metal–protein binding, through a balance of covalent and ionic interactions, drives metal subcellular distribution. Models fitted to species-specific groups showed good predictive performance on validation data, with concordance correlation coefficient (CCC) ranging from 0.60 to 0.78. The final models accurately matched observed relative contributions (CCC = 0.79–0.89). Application of the validated models to 20 data-poor TCEs suggested that some of these elements (e.g., In, Ga, Bi) may pose a greater hazard, as their predicted accumulation levels in metal-sensitive fractions were comparable to those of studied toxic elements (e.g. Hg, Au, Pt). In contrast, some TCEs (e.g., Li) exhibited low predicted values in sensitive fractions, indicating a lower toxicological potential. Shapley additive explanations revealed three metal groups based on how subcellular accumulation is modelled. Overall, QICARs provide a robust framework for gaining insights into how chemical properties shape subcellular distribution, and predicting TCEs of concern in risk assessments.

Disclaimer/Disclosure: This work was funded by Fonds de Recherche du Quebec - Bourses d'excellence pour étudiants étrangers (PBEEE; https://doi.org/10.69777/371542) and Bourses de doctorat en recherche Nature et Technologies (https://doi.org/10.69777/368178).

2.14.T-05 Temporal Trends in Critical Minerals and Rare Earth Element Accumulation in Lake Sediments Near a Copper Smelter

Elsa Dejoie[1], Igor Lehnherr[2], Gabriel Philippe[2], Greg Lawson[3], Amber Gleason[3] and Jane Kirk[3] (1)Department of Geography, Geomatics and Environment - University of Toronto Mississauga, (2)Department of Geography, Geomatics and Environment - University of Toronto Mississauga Canada, (3)Environment Canada

The increasing demand for critical metals driven by emerging technologies and the transition toward renewable energy has raised concerns regarding their environmental accumulation and long-term impacts. In this study, we investigated the temporal variability of rare earth elements (REEs) and critical minerals in lake sediments and assessed their potential links to industrial activities. Dated sediment cores were collected from six lakes surrounding Rouyn-Noranda (Quebec, Canada), an area historically impacted by smelting activities.
Cores were dated using Lead-210 radiometric dating, and concentrations of 59 metal(loid)s and trace elements were analysed to construct a time series of deposition spanning from the pre-smelter period to the present day. Here we focus specifically on selected REEs (e.g., Ce, La, Nd, and Pr), smelter-related elements (e.g., Cu, Ag, and Te), battery-related critical metals (Co and Li), and Ni due to its association with both metallurgical processes and battery technologies. Temporal trends were reconstructed and interpreted using sediment fluxes and concentration-based enrichment factors (EFs). EFs were calculated for each time interval as the ratio of Aluminium-normalized elemental concentrations to mean baseline values measured during 1890-1920.
Results showed strong enrichment of smelter-related elements, particularly Cu, Ag, and Te, in the two lakes located closest to the smelter and downwind of prevailing winds, with enrichment factors exceeding 60. By contrast, REEs exhibited more moderate enrichment (EF between 1.6 and 2), with elevated fluxes observed both in Drolet Lake (closest to the smelter) and Perron Lake (the farthest lake), suggesting that REE accumulation cannot be explained by proximity to industrial emissions.

Our results demonstrate the strong historical influence of smelting activities on the deposition and accumulation of certain critical minerals in surrounding lakes. However, the spatial pattern of REE enrichment in these lakes indicates additional local controls and non-smelter sources (e.g., erosion).

2.14.T-06 Early-Life Exposure and Maternal Transfer of Trace Elements Including Technology-Critical Elements on the Endangered Beluga (Delphinapterus leucas) of the St. Lawrence Estuary, Canada

Maylie Houle[1], Veronique Lesage[2], Stephane Lair[3], Maikel Rosabal[4] and Richard St-Louis[5] (1)University of Quebec at Rimouski (UQAR), (2)Fisheries and Oceans Canada, (3)University of Montreal, (4)University of Quebec in Montreal (UQAM), (5)University of Quebec in Rimouski (UQAR)

The St. Lawrence Estuary, home to an endangered beluga (Delphinapterus leucas) population, is heavily impacted by human activities. Since 2010, reduced survival of calves and gestating females has lowered recruitment and population growth. The beluga exposome remains incompletely characterized, particularly regarding toxic trace elements (TEs), including some technology-critical elements (TCEs), during early life stages. This study assesses the metallic exposure of beluga calves over a 14-year period and evaluates associated risks to the population. We report the first detection and quantification of several TEs (Hg, Pb, Cd, As, Cu, Ag, Se, Tl, Co), counting some TCEs (Li, Sb, Pd, Pt, Y, La, Nd, Sm, Gd) in the livers of stranded calves and fetuses collected through a specialized program between 1988 and 2022 (n = 51). Analyses were conducted using inductively coupled plasma triple quadrupole mass spectrometer (ICP-QQQ) and a direct mercury analyzer (DMA). The highest TE concentrations (µg/g dry weight) were found for Cu (84 ± 113), Se (2.4 ± 1.9), and Ag (0.8 ± 1.4) while for TCE concentrations, Li (0.334 ± 0.726), Nd (0.13 ± 0.45), and La (0.12 ± 0.40) were more abundant. Concentrations of Cu, Ag, and Co exceeded provincial norms for the protection of aquatic species, suggesting potential risks to calves. Generalized additive models (GAMs) revealed temporal trends from 2008 to 2022, with significant increases ($p < 0.05$) in Sb, Pd, Cu, Ag, Tl, decreases in Li, Pt, Pb, As, and non-linear fluctuations in Cd and Co. These trends likely reflect maternal contaminant burdens, as higher concentrations of some elements (Sb, Nd, Cu, Tl, Co) were found in fetal livers compared to those of their gestating mother, indicating transplacental transfer of non-essential elements. A principal component analysis (PCA) indicated a possible effect of carcass decomposition on metal composition, especially for essential metals (e.g. Na and Mg) as well as Li and Co. Proteomic analyses were also conducted to assess defense mechanisms and potential toxicological effects associated with exposure in calves. These results provide novel data on early-life exposure to metallic contaminants, prior to prey consumption. They also improve the understanding of how TEs have the potential to affect belugas at a critical developmental stage and contribute to ongoing conservation efforts for this endangered population.

Technology-Critical Elements: From Sources, Exposure and Effects to Environmental Risk Assessment

2.14.P-We188 Understanding the Effects of Rare Earth Elements in Mixtures on Benthic Organisms: From Toxicity Tests to Mechanisms of Actions

Marie Lefranc[1], Alexis Dehaudt[1], Maggy Lépine[1], Lekha Sleno[2], Marc Amyot[3] and Maikel Rosabal[1] (1)University of Quebec in Montreal (UQAM), (2)University of Quebec in Montreal, (3)University of Montreal

(UdeM)

Rare Earth Elements (REEs) are increasingly used in multiple industrial applications, including green technologies, leading to REE contamination in aquatic environments. These contaminants commonly occur in mixtures and are largely found in lakes and rivers sediments where they have the potential to cause deleterious effects to benthic organisms. However, little is known about the REE toxicity mechanisms in sediment-dwelling animals, especially in mixtures, which has delayed the establishment of regulations.
To fill this gap, the objective of this study was to assess the toxicity, the interactions and resulting effects on the crustacean Hyalella azteca as well as the mode of actions of the Lanthanum (La), Gadolinium (Gd) and Yttrium (Y) by multi-omics approaches.
Standardized sediment toxicity tests were performed using the ISO:16303 methodology with individual REE and the isobologram methodology for the three binary mixtures of La/Gd, Gd/Y and Y/La. The toxicity was assessed with survival and growth, and the proteomic and metabolomic responses were characterized by Liquid Chromatography-High Resolution Tandem Mass Spectrometry (LC-HRMS/MS) in whole larvae for the Y/La mixture.
The toxicity tests showed toxicity differences between the individual REEs (EC50Y < EC50Gd < EC50La ; respectively 146 < 218 < 380 mg.kg-1 dw for growth inhibition) and mostly additive effects on the binary mixtures of La/Gd, Gd/Y and Y/La. Similar proteomic profiles were found for La and Y individually with some differences, suggesting some element-specific effects. Metabolomic and proteomic analyses are currently being carried out for the mixture. New results are expected to give more information on the impact of the REE on biochemical processes as well as to reveal potential new biomarkers for the REEs exposure in this species.

2.14.P-We189 Mobility of Rare Earth Elements in Discontinuous Permafrost Soils of Northern Québec

Kristin Mueller[1], Chloé Rivest[2], Tidiane Camara[1], Eloïse Giroux[2], Dominic Larivière[2] and Raoul-Marie Couture[2] (1)Centre d'expertise en analyses environnemental du Québec (CEAEQ), Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs (MELCCFP), (2)Department of Chemistry, Université Laval

The growing demand for rare earth elements (REEs) to support clean energy technologies is driving increased exploration of northern mining regions, raising concerns about their environmental fate in sensitive subarctic ecosystems. This study investigates the mobility, speciation, and retention mechanisms of REEs in representative northern Québec soils, integrating laboratory experiments and geochemical modeling. Soils were collected in contrasting discontinuous permafrost landscapes nearby the communities of Whapmagoostui–Kuujjuarapik (Nunavik, Canada), namely permafrost (palsa), burnt forest, and coastal sandy soils. Physicochemical characterization revealed soils dominated by quartz-rich matrices but with a high variability in organic matter content (1.5–85%), pH (4.5–7), and mineralogy. Batch adsorption–desorption experiments and ICP-MS analyses were combined with inverse kinetic modeling to evaluate REE behavior under environmentally relevant conditions. Results demonstrate that REE mobility is strongly controlled by soil composition, particularly organic matter (OM) and mineral phases. Permafrost soils exhibited the highest adsorption capacity (up to ~226 µg g^{-1} at equilibrium), driven by strong complexation with humic substances and high cation exchange capacity. In contrast, low-OM mineral soils showed lower retention and greater potential for remobilization. Kinetic experiments indicated rapid adsorption (<1 h), consistent with pseudo-second-order behavior. Desorption experiments further revealed that REE release varies with soil type and

solution chemistry, with enhanced mobilization in the presence of dissolved organic matter. Light versus heavy REE fractionation patterns also differed across soils, reflecting distinct adsorption and complexation mechanisms. Overall, this work provides new experimental and modeling constraints on REE behavior in subarctic soils and highlights the critical role of organic matter in limiting mobility. These findings are directly relevant for environmental risk assessment and predictive modeling of REE mobility associated with northern mining development.

2.14.P-We190 Assessing the Lethal and Sublethal Effects of Platinum in Freshwater Invertebrates

Madeleine Kim[1], Johann Memmel[2], Kallie Shires[3], David McNabney[3], Erin Leonard[2] and Ève Gilroy[3] (1)Wilfrid Laurier University, Environment and Climate Change Canada, (2)Wilfrid Laurier University, (3)Environment and Climate Change Canada

Technology-critical elements (TCEs) are a group of metals that are increasingly used in advanced technologies and are emerging contaminants of environmental concern. Among the TCEs, platinum (Pt) is specifically valued for its role in catalytic converters, hydrogen production, fuel cells and medical applications, yet its toxicity to freshwater organisms remains poorly understood. This study evaluated the toxicity, bioaccumulation and metabolic effects of Pt in two freshwater invertebrates, the freshwater gastropod, Planorbella pilsbryi, and the crustacean, Daphnia magna. Adult P. pilsbryi were exposed to gradient concentrations of platinum dichloride (PtCl2) for 28 -day to assess survival, growth, and reproduction. Embryonic snail exposures were also conducted to evaluate developmental endpoints. Since standard toxicity endpoints provide limited mechanistic information, untargeted metabolomics will be performed on exposed P. pilsbryi tissues to identify metabolic pathways affected by Pt exposures. For D. magna, acute (48-hour) and chronic (21-day) exposures were conducted to assess survival, and reproduction. Pt exposure showed concentration-dependent effects in both freshwater invertebrates. In P. pilsbryi, somatic growth (shell length and weight) showed significant reductions even at concentrations where survival remained near 100%, indicating that growth was a sensitive sublethal endpoint. Snail survival and embryo development were adversely affected at higher concentrations. Notably, D. magna showed greater sensitivity to Pt exposure than adult snails, with survival declining at significantly lower concentrations. Ongoing metabolomic analyses will further provide insight into potential mechanisms of Pt toxicity. These findings show that Pt produces both lethal and sublethal effects in freshwater invertebrates. By providing critical toxicity data for this emerging TCE, this research will support the development of Federal Environmental Quality Guidelines (FEQGs), which are important for protecting aquatic life and maintaining ecosystem health. By improving our understanding of the effects of Pt on freshwater species, this research will help bridge ecological research and regulatory needs.

2.14.P-We191 From Toxicity Tests to Multi-Omic Approaches: Elucidating Platinum and Palladium Interactions and Effects on Chironomus riparius

Alice Carle[1], Maikel Rosabal[1] and Marc Amyot[2] (1)UQAM, (2)UdeM

Emissions of platinum (Pt) and palladium (Pd) are increasing due to growing industrial use, leading to accumulation in freshwater sediments where benthic organisms may be highly exposed. Most ecotoxicological studies investigate single metal exposure in water, therefore, little information from molecular to organismal levels exists on mixtures in sediments.

We aimed to characterize the toxicological, subcellular metal-handling and molecular responses of the insect Chironomus riparius exposed to Pt and Pd, individually and in mixtures. Standardized sediment toxicity tests were performed by fixing the concentration of one metal while increasing the other. Survival, growth and bioaccumulation were evaluated to determine the nature of Pd-Pt interactions. Subcellular measurements were also performed to understand the metal distribution among detoxified and sensitive fractions. Alterations on the proteome and metabolome (targeting amino acids) were evaluated on whole larvae to identify effects on biological processes and potential biomarkers of Pd- and Pt-induced toxicity.
Toxicity tests revealed significant antagonistic interactions, with less-than-additive effects observed at the highest mixture concentrations. Subcellular partitioning showed that most Pt and Pd accumulated in detoxified compartments, with granules accounting for 50–70% of the total metal burden. Proteomic analyses identified 926 proteins, of which 291 and 218 were significantly affected by individual Pd and Pt exposures, respectively, while mixtures induced significant changes in 195 to 347 proteins. Synthesis and turnover of proteins as well as energy production and mitochondrial metabolism were among the most impacted biological processes. Metabolomic analyses identified 262 putative metabolites, including 89 and 96 significantly altered following individual Pd and Pt exposures, respectively. Metabolites associated with amino acids and amine derivatives represented the most affected functional groups.
Overall, this study contributes to the advanced mechanistic information for these two emerging metals, which eventually supports the need for improved protection of aquatic ecosystems.

Disclaimer/Disclosure: Fonds de recherche du Québec–Nature et technologies (FRQNT)
Grant number 309685

2.14.P-We192 Subcellular Partitioning of Elements Reveals Chemical Drivers of Intracellular Distribution in Fish Liver Using QICAR Modeling

Luana Hainzenreder Bauer[1], Antonin Landa[1], Cândido Carvalho Rodrigues[1], Douglas H. Adams[2], Benjamin D. Barst[3], Marc Amyot[4] and Maikel Rosabal[1] (1)University of Quebec in Montreal (UQAM), (2)Fish & Wildlife Research Institute; Florida Fish & Wildlife Conservation Commission, (3)University of Calgary, (4)University of Montreal (UdeM)

Over recent decades, the increased release of both essential and non-essential elements into the environment has led to simultaneous multielement exposures in aquatic organisms. Understanding the mechanisms governing the accumulation of these elements at subcellular level is essential for interpreting their potential harm to aquatic wildlife. However, the extent to which multiple elements are known to accumulate in detoxified or sensitive subcellular fractions and whether intracellular distribution patterns can be predicted from their intrinsic chemistry remain unclear. Here, we combined empirical data and quantitative ion character–activity relationship (QICAR) modeling to investigate the subcellular distribution of 20 elements in the livers of five estuarine fishes (Ariopsis felis, Archosargus probatocephalus, Centropomus undecimalis, Sciaenops ocellatus, and Sphyrna tiburo) from the Indian River Lagoon (Florida, USA). Species-specific fractionation protocols separated detoxified (granules, cytosolic heat-stable proteins) and metal-sensitive (mitochondria, lysosomes + microsomes, cytosolic heat-denatured proteins) compartments. To evaluate the prediction of these patterns, 19 physicochemical descriptors were compiled and related to subcellular distributions using tensor generalized additive models. Observed patterns for class B (total Hg, methyl Hg, Cd, Cu), class A (Ca, Mg, K, Rb, Sr, Y, Pr, Nd), borderline (Fe, Zn, Co, Mn, V), and other elements (Mo, Se, As) were broadly consistent with their

chemical affinities. Exceptions were observed with soft metals total Hg/methyl Hg, which were predominantly associated with the sensitive compartment, and largely detoxified hard elements K and Rb. Across models, covalent index was the best descriptor for subcellular distribution (75–86%), followed by ionic index (5–23%), and atomic number (<9%). Multivariate ordination further indicated that observed patterns align with traditional class A, class B, and borderline grouping based on ligand affinity. These findings demonstrate that element intracellular partitioning is strongly dictated by their physicochemical properties, highlighting QICAR modeling as a robust framework for predicting cross-species element behavior in fish, offering a scientific basis for identifying elements of concern and exploring further information regarding data-poor elements.

2.14.P-We193 From Exposure to Effects: Bioaccumulation and Biological Responses To Trace Metal (TE) Including Technology-Critical Elements (TCE) in Fish Near a Major E-Waste Smelter

Antonin Landa[1], Louis-Philippe Bedford[1], Thibaut Jouy[1], Alexane Gaudet[2], Marc-Olivier Roberge[2], Martin Bélanger[2], Marc Amyot[3] and Maikel Rosabal[4] (1)Université du Québec à Montréal (UQAM), (2)Direction de la gestion de la faune de l'Abitibi-Témiscamingue. Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs, (3)University of Montreal (UdeM), (4)University of Quebec in Montreal (UQAM)

In a context of increasing mining and metallurgical recycling activities, the release of trace elements (TEs), including technology-critical elements (TCE), into aquatic ecosystems raises concerns about their effects on aquatic wildlife. Despite numerous studies on their biological effects under controlled conditions, understanding of TE toxicity in the field remains poorly explored. In this study, we assess TE exposure (including some TCE) and effects in field-collected fish using an integrative approach linking metal speciation, bioaccumulation, and multi-level biological response. Three piscivorous species (Esox lucius, n = 56; Sander vitreus, n = 56; Perca flavescens, n = 68) were sampled in eight lakes located near the Horne smelter (Rouyn-Noranda, Québec), the largest electronic waste recycling facility in North America. This facility represents a major historical source of TE emissions and has led to repeated exceedances of water and sediment quality guidelines for the protection of aquatic life. Concentrations of various TEs in liver and muscle were quantified using ICP-MS/MS and related to toxicological and biochemical biomarkers to assess physiological disturbances. Results show that distance from the smelter and fish age are the main determinants of metal bioaccumulation. Strong spatial gradients were observed, with enrichments up to 40× for Cu and 20× for Cd, as well as for rare earth elements (up to 90× for Ce and 24× for La). Tissue concentrations were significantly correlated with dissolved concentrations in water of some TEs (R^2 = 0.51–0.84), supporting the biomonitoring potential of the three studied species. Biomarkers of oxidative stress revealed element-specific responses, including increased antioxidant capacity associated with Cu and Zn, while lipid peroxidation generally decreased with increasing TE levels (including Cd) as compensatory biological defenses. Condition indices (hepatosomatic and Fulton indices) showed consistent negative relationships with metal burdens, indicating organism-level impacts. Additional biochemical endpoints related to metabolic activity and energy reserves are currently under analysis to further assess the biochemical disturbances associated with exposure to multiple TE. These findings highlight the value of these species as biomonitors, supporting their use in environmental risk assessment of aquatic ecosystems while some metal-exposure effects were revealed.

2.14.P-We194 Metal-Biomolecule Interactions in Chlamydomonas reinhardtii: SEC-ICP-

MS, Proteomics and ESI-MS/MS

Claude Fortin[1], Anne Crémazy[1], Maikel Rosabal[2] and Heidi Fortin[1] (1)Institut national de la recherche scientifique, (2)Université du Québec à Montréal

The rapid development of new technologies worldwide is leading to an increase in emerging contaminants, such as platinum (Pt), lanthanum (La), and cerium (Ce) in aquatic environments. However, these technology-critical elements are rarely included in toxicological studies, especially when combined with others like copper (Cu), silver (Ag), cadmium (Cd), cobalt (Co), uranium (U), and nickel (Ni). This limits our ability to assess their toxicity, mixture interactions, and predict ecological risks.

To address these gaps, we investigated the intracellular handling and interactions of these metals in Chlamydomonas reinhardtii, a unicellular green alga. Cells were exposed to two metal mixtures (10 and 100 nM) then fractionated into five subcellular compartments, some considered sensitive to contamination (organelles and heat sensitive proteins) and others involved in detoxification (granules, debris and heat stable proteins). The subcellular distribution provides insight into intracellular metal localization and cellular responses.

To further explore metal-biomolecule interactions, an environmental metallomics approach was applied using size exclusion chromatography coupled to inductively coupled plasma mass spectrometry (SEC-ICP-MS). This technique separates biomolecule-metal complexes by size, allowing targeted analysis of two subcellular fractions: organelles and heat-stable proteins (HSP) from the cytosol. Proteomic and peptidomic analyses were then used to identify the proteins and peptides forming these metal complexes. Several proteins, including thioredoxin and oxygen-evolving enhancer proteins were identified as potential metal-binding ligands. However, the limited resolution of SEC-ICP-MS for separating proteins according to molecular size restricted the identification of individual metal-binding complexes. Consequently, ESI-MS/MS will be employed on the HSP fraction to achieve a more detailed characterization of metal-phytochelatin complexes and intracellular detoxification mechanisms. Cd, Co, and Cu are expected to be the primary metals associated with phytochelatins.

2.14.P-We195 Bioaccumulation and Toxicity of Platinum and Palladium in the Atlantic Salmon (Salmo salar)

Julien Michaud-Valcourt[1], Anne Crémazy[1], Patrice Couture[1] and Claude Fortin[1] (1)INRS

Mining activities and human uses of platinum (Pt) and palladium (Pd) have been directly linked to the release of these metals into the environment. Their presence, mobility, bioavailability and ability to cause harmful effects in aquatic ecosystems have already been documented. Yet, gaps remain regarding their ecotoxicological risks, particularly regarding the availability of quality effect concentrations for these metals . This lack of data on their toxicity is, in fact, the reason why there are no water quality guidelines (WQG) for the protection of aquatic life for these metals in Canada, even though the country is the third-largest producer of these metals in the world. In this context, our objective was to evaluate the effects of acute exposure (96 hours) to Pt and Pd on the survival of juvenile Atlantic salmon following OECD guideline 203 and to derive lethal concentration values (96-h LCx) to contribute to the establishment of an acute WQG. In addition, the distribution of Pt and Pd within the organism, as well as their ability to cause oxidative stress, were studied. Platinum organotropism (dry weight

basis) increased as follows: muscle < carcass (remaining body tissues) < liver ≈ gills. In the case of Pd, the accumulation, measured only in euthanized fish, appears to be disproportionately concentrated in the gills. A 96-h LC50 of 0.9 µM Pd (95.8 µg Pd/L) and a 96-h LC10 of 0.8 µM (85.1 µg Pd/L) was measured for Pd, while no mortality was observed for Pt within the test concentration range (up to 46 µM Pt (9000 µg Pt/L), despite signs of respiratory difficulties observed in exposed fish. This 58-fold difference between Pt NOEC and Pd LC10 cannot be explained by a difference in total bioaccumulation as accumulation in the gills is only expected to be 26 times higher at a given concentration based on bioconcentration factors. We found no evidence that either metal affected the activity of three key antioxidant enzymes in the liver (catalase, superoxide dismutase and Glutathione S-transferase), or that they induced lipid peroxidation, suggesting that exposure to these metals does not result in oxidative stress and is not the cause of the mortality. In terms of ecological risk, the 96-h LC50 for Pd was higher than concentrations measured in contaminated environments, where the maximal reported concentration is 0.06 µM Pd, but highlights the need to study the sublethal effects of this metal in order to adequately assess the chronic risks to fish.

2.14.P-We196 Interactions and Associated Effects of Rare Earth Elements and Coexisting Elements in Mixtures on Hyalella azteca

Alexis Dehaudt[1], Angélique Galiano[1], Marie Lefranc[1], Claude Fortin[2] and Maikel Rosabal[1] (1)UQAM, (2)INRS

Rare earth elements (REEs) are a group of 17 metals with exceptional properties that make them nearly impossible to substitute in new technologies (e.g., renewable energy, military usage). Hence, REEs are currently contaminants of emerging interest in our aquatic ecosystems. Although a few pioneering studies were conducted, the interactions and combined effects among REEs on benthic organisms remain poorly understood, as is our knowledge of the effects of co-exposure to REEs and coexisting contaminants such as uranium (U). This work aims to determine the interaction and resulting effects on the freshwater amphipod Hyalella azteca exposed to contaminated sediments containing i) a mixture of REEs, and ii) REEs combined with U.
We performed toxicity tests on H. azteca exposed to REEs under different conditions (only Ce or Y; Ce+light REEs or Y+heavy REEs; Ce or Y + 14 REEs) at three different concentrations (low, medium, high) covering environmental levels. Other toxicity tests were conducted with REEs at low concentration with an increasing range of U (0.5–40 mg/kg). Survival and growth rates were used as biological responses to identify mixture interactions. A reduced survival (%) of H. azteca was only observed for Ce and Y at high levels for the condition Ce+ 14 REEs and Y+ 14 REEs compared to individual metal exposures (only Ce or Y) ($p < 0.05$). Also, H. azteca had a significantly lower growth when exposed to Ce + 14 REEs at medium concentrations, and to Ce + light REEs and Ce + 14 REEs at high levels compared to amphipods exposed to individual Ce or Y. For Y, a marked growth rate reduction (up to -50%) was only reported for the condition Y + 14 REEs at high levels. These results suggest possible additive effects (non-interaction) or more-than-additive effects (synergism) of REEs when exposed together. Results for U exposures showed no clear significant differences in survival or in growth rates. Quantification of metals in organisms, sediments, and porewater is underway to better assess exposure conditions as well as to identify potential interactions in metal uptake steps. Proteomic analysis (bottom-up variant) are also planned to better understand the underlying mechanisms of sublethal REEs interactions for some specific conditions. In terms of risk assessment, our results highlight the need to consider potential toxicological interactions among REEs at environmentally relevant concentrations to develop more efficient and realistic guidelines.

2.14.P-We197 Human Health and Environmental Risk Assessment of Rare Earths for the Opening Mine in Nunavik

Dominic Ponton[1], Charles Gauthier[1], François Dion[1], Ruben Jacova[1], Emmanuelle Becaert[2], Michael Sanborn[1], Valérie Tremblay[1] and Sonia Labrecque[1] (1)AECOM, (2)Torngat Metals

As part of the Torngat Metals Inc. rare earth mining project, AECOM was mandated to conduct the human health and ecological risk assessment. In addition to the mine site, this assessment also covers the areas targeted for the construction of the access road and the port facilities intended for transshipping the concentrated ore to a purification plant located in Sept-Îles. As part of this study, sampling of water, sediments, soils, and various organisms (e.g., vegetation, ptarmigan, etc.) present on the sites was carried out. A first challenge is the lack of information regarding the toxicity of rare earth elements. Few reference values are available, and when they are, they must be validated. Several values were generated de novo. These values will be presented, discussed, and compared with the estimated doses for mammalian and human receptors. In addition to the characterization of baseline levels, exposure estimates for rare earth elements and radionuclides for the construction, operation, and closure phases will also be presented. The concentrations observed in the lichen at the mine site were found to be higher than those measured in lichen from the surrounding reference sites. Moreover, the results show that the detection limits offered by accredited laboratories are often too high to allow for an accurate assessment of baseline levels, which can lead to an overestimation of risks and an apparent reduction in the magnitude of impacts.

3. Wildlife Toxicology, Ecology and Stress Response

Bidirectional Framework: Evaluating Exposure to Contaminants in Birds in Lab and Wildlife Studies

3.01.T-01 Detection of Perfluoroalkyl Acid Precursors in Wild Birds Guides Investigation of Their Biotransformation

Kailee Hopkins[1], Melissa McKinney[1], Robert Letcher[2], Ramela Koumrouyan[1], Jessica Head[1], Tristan Smythe[2], Amandeep Saini[2], Natalie Karouna-Renier[3] and Kim Fernie[2] (1)McGill University, (2)Environment and Climate Change Canada (ECCC), (3)U.S. Geological Survey (USGS)

Concern regarding the persistence and toxicity of bioaccumulative perfluoroalkyl acids (PFAAs) has led to phase-outs or restrictions of many of these compounds globally. Consequently, manufacturing and environmental monitoring have shifted focus toward PFAA precursors, which some are not yet regulated under the UN Stockholm Convention and may be biotransformed into metabolites, including terminal PFAAs. Yet, PFAS precursor biotransformation pathways in wildlife remain poorly understood. Here, we used complementary field and laboratory approaches to investigate the occurrence and potential biotransformation of PFAA precursors in birds. Our objectives were to first evaluate the accumulation of PFAAs and their precursor compounds in a wild bird species, and second to investigate the potential biotransformation of selected precursors into metabolites such as the long-chain PFAAs. In 2021, concentrations of 46 per-and polyfluoroalkyl substances (PFAS), including 25 precursors, were measured in abiotic and biotic compartments associated with the food web of the tree swallow (Tachycineta bicolor), a mid-trophic passerine species in

southwestern Ontario. In overall PFAS profiles, 5:3 fluorotelomer carboxylate (5:3 FTCA) was the dominant PFAS precursor detected in aquatic invertebrates (62 %) in contrast to the profiles in tree swallow gastrointestinal tracts (16 %) and livers (0 %), a major site of metabolism and longer-term storage. PFAS profiles in air were dominated by the fluorotelomer alcohols (FTOHs), with 10:2 FTOH comprising 18 % of PFAS concentrations. In contrast, tree swallow gastrointestinal tracts and livers were dominated by perfluorooctane sulfonic acid (PFOS; 41-48 %), and long-chain perfluorocarboxylic acids (8-10 %), despite lower proportions of these PFAS in other food web compartments (2-4 %), suggesting potential biotransformation of precursors to PFAA metabolites. To further investigate precursor biotransformation at the embryonic stage, a dosing study was conducted with Japanese quail (Coturnix japonica). Eggs were dosed on embryonic day 0 with 100 ng/g bisperfluorooctyl phosphate (6:2 diPAP), 5:3 FTCA, or 10:2 FTOH (n= 30/dose group), and concentrations of precursors and potential metabolites were measured following major organ development and pre-hatch. Comparisons between precursor compounds and PFAA metabolites in embryonic quail will be presented at the conference.

3.01.T-02 Per- and Polyfluoroalkyl Substances in the Terrestrial Food Web of European Starlings (Sturnus vulgaris) at a Historically Contaminated Landfill

Julianna Colafranceschi[1], Tristan Smythe[2], Shane de Solla[1], Robert Letcher[2] and Emily Choy[1] (1)McMaster University, (2)Environment and Climate Change Canada (ECCC)

Per- and polyfluoroalkyl substances (PFAS) are a class of over 14,000 anthropogenic chemicals. A growing number of PFAS are proving to be ubiquitous, persistent, and bioaccumulative environmental contaminants, with exposure threatening human and wildlife health. Certain avian species, such as the terrestrial generalist omnivore European starlings (Sturnus vulgaris), can act as reliable indicators for monitoring PFAS contamination in local terrestrial environments. Eggs from these birds have been used by Environment and Climate Change Canada's (ECCC) Integrated Chemicals Mixtures Project (ICMP) since 2023 and the Chemical Management Plan's (CMP) Environmental Monitoring and Surveillance since 2009 as indicators of terrestrial PFAS pollution at sites across Canada. Despite the long-term use of starling eggs for monitoring, little is known about the dietary preferences and exposure to PFAS of birds at these sites. As diet is a key route of PFAS exposure, this lack of knowledge limits the ability to link environmental terrestrial contamination to observed PFAS concentrations in starling eggs. This study investigates PFAS concentrations and patterns throughout the food web of European starlings at a PFAS-contaminated landfill in Brantford, Ontario, Canada. Starling eggs from this site have consistently had the highest PFAS concentrations of all CMP-monitored sites since 2009, with PFOS concentrations in eggs ranging from 224 ng/g to 1486 ng/g ww (wet weight). During the 2024 and 2025 starling breeding season, diet-relevant terrestrial invertebrates were collected using sweep nets, pitfall traps, malaise traps, and a modified ligature method. Invertebrate samples were identified to Order and analyzed for a suite of 35 PFAS using a UPLC-MS/MS-based analytical method. Earthworms (Order Opisthopora) had the highest PFAS values amongst all the Orders, with sum perfluoroalkyl carboxylic acids (PFCAs) averaging 538 ng/g ww and sum perfluoroalkyl sulfonic acids (ΣPFSAs; mostly PFOS) averaging 1088 ng/g ww. Millipedes (Order Julida) also had elevated sum PFCA concentrations, with samples ranging from 265 to 568 ng/g ww. As these invertebrates form the base of many avian and mammalian food webs, this work will improve our understanding of contaminant transfer routes and bioaccumulation in wildlife, as well as expand upon existing PFAS monitoring efforts in Canada and inform future policy changes.

3.01.T-03 How Do Spray Applications of Agricultural Pesticides Impact Avian Energetics and Metabolism?

Bronte Bowling[1], Catherine Ivy[1] and Christy Morrissey[1] (1)University of Saskatchewan

Following frequent and repeated pesticide spray applications, many songbirds in agricultural landscapes experience exposure across multiple routes during periods of elevated energetic demand, such as breeding, growth or migration. Most studies focus on oral toxicity, yet inhalation and dermal exposure remain especially understudied in avian systems. Our objective is to quantify pesticide induced changes in metabolic efficiency and energetics following simulated spray events causing dermal and respiratory exposure and evaluate associated dose–response relationships. Concurrently, we will quantify wild avian acoustic activity using autonomous recorders before and after agricultural pesticide spray events. We hypothesize that whole body spray exposure reduces metabolic rate by enabling rapid pulmonary uptake that bypasses hepatic detoxification, triggering oxidative stress and inflammation that impair gas exchange efficiency. We also hypothesize bird call frequency will decrease after a spray event and the magnitude will differ among species due to physiological sensitivity to toxins. To test this, we conducted controlled captive trials exposing juvenile House Sparrows (Passer domesticus) to two repeated whole body aerosolized applications of environmentally relevant doses, based on standard crop application rates, of commercial formulations containing either glyphosate (herbicide) or lambda cyhalothrin (insecticide). Measurements of daily food intake, body mass, activity using sensor plates, and resting and basal metabolic rates using open flow respirometry show compound-specific energetic changes associated with exposure. Liver and lung tissues were collected post exposure and are being processed histologically to assess cellular damage, inflammation, and tissue level pathology. We also deployed bioacoustics recorders across Saskatchewan and Alberta and paired this with producer spray data. Year one's data showed substantial decreases in call rate after a fungicide spray event in Red-Winged and Yellow-headed Blackbirds across 14 events and 13 fields. This study provides new mechanistic evidence on how commercial pesticide formulations interact biologically across dermal and inhalation exposure routes, supporting improved pesticide regulation that aligns with Canada's biodiversity protection goals.

3.01.T-04 Comparing Sensitivity to Polycyclic Aromatic Hydrocarbons in Japanese Quail and Double-Crested Cormorant

Jonathan Sangiovanni[1] and Jessica Head[2] (1)McGill University; Dalhousie Univerisity, (2)McGill University

Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous chemical stressors. Although birds are receptors of concern for PAHs, the mechanisms underlying differential species sensitivity to exposure are poorly understood. The current model for predicting interspecies differences to PAHs is extrapolated from the Adverse Outcome Pathway (AOP) for a related class of chemicals that links the potency for Aryl Hydrocarbon Receptor 1 (AHR1) activation by ligands, induction of cytochrome P4501a (CYP1A) biotransformation enzymes, and mortality. However, recent findings suggest that this model does not apply to PAHs. Previous results from our group showed a 30-fold difference in sensitivity (LD50) between model (Japanese quail; Coturnix japonica) and free-ranging (double-crested cormorant; Nannopterum auritum) bird species following exposure to benzo(a)pyrene (BaP) via egg injection, although these species were predicted to be equally sensitive to PAHs because of similarities in the AHR1 primary sequence. Here, we evaluate the molecular mechanisms of PAH toxicity among birds with the AOP for AHR1 activation as a starting point. First, we explored interspecies sensitivity at the molecular level by assessing the potency of protein-ligand interactions between six individual

PAHs and the AHR1 in an in vitro reporter assay using cloned constructs from quail and cormorant. Then, we used targeted qPCR to assess basal expression and the relative induction of CYP1 genes and gas-chromatography mass-spectrometry to measure the rate of depletion of BaP in developing eggs until mid-incubation. Collectively, our results show that metabolism downstream of the molecular initiating event is critical for species differences to BaP. Our in vitro assay elicited an equal response between birds, yet the more resilient species to BaP exposure in vivo (quail) was more efficient at metabolizing BaP (faster rate of depletion). Furthermore, quail, and not cormorant, had transcriptionally responsive extra-embryonic tissues (chorioallantoic membrane (CAM), suggesting a potential protective role of this tissue. In summary, the current model for predicting avian sensitivity to PAHs is insufficient to predict lethal effects across species. We emphasize the importance of chemical metabolism in mediating PAH toxicity. Cross-species predictions for PAH sensitivity will improve with a deepened understanding of physiological and life history traits that influence chemical clearance in developing birds.

3.01.T-05 Are Subtle Physiological Changes Identified Using Targeted Metabolomics Associated With Per- and Polyfluoroalkyl Substances Exposure in Nestling Tree Swallows (Tachycineta bicolor)?

Danielle MacNeil[1], Kim Fernie[2], Kailee Hopkins[3], Tristan Smythe[2], Robert Letcher[2], Melissa McKinney[3] and Emily Choy[1] (1)McMaster University, (2)Environment and Climate Change Canada (ECCC), (3)McGill University

Understanding the effects of (emerging) contaminant exposure on birds remains challenging, but metabolomic approaches can reveal potential pathways of effects. In this study, possible associations of the class of per- and polyfluoroalkyl substances (PFAS) with subtle changes in lipid metabolism, oxidative stress and other physiological systems were investigated in nestling tree swallows (Tachycineta bicolor) using targeted metabolomics. In 2022 and 2024, 10-day-old nestlings were collected from up to six study sites across southern Ontario (N = 24 and N = 43, respectively), including three wastewater treatment plants (WWTPs), a landfill, a former agricultural rural site, and a long-term reference site. Concentrations of multiple bioaccumulative PFAS compounds differed among sites and were highest in nestlings at the landfill and lowest in nestlings at the reference site and Dundas WWTP. Similar site-related patterns were observed in metabolites associated with lipid metabolism, particularly in nestlings from the landfill. Carnitines are metabolites that transport fatty acids into mitochondria for energy production. Some carnitines (PC1 = 41%) were similar in nestlings at the landfill and Brantford WWTP but differed in nestlings at sites downstream of the other two WWTPs, the rural site and reference site. Other carnitine measures (PC2 = 14%) were similar in nestlings downstream of all three WWTPs but differed from the reference site. Similarly, nestlings downstream of these WWTPs had similar dietary fatty acid profile patterns, particularly for the essential omega-3 fatty acids eicosapentaenoic acid (20:5n3), docosapentaenoic acid (22:5n3), and docosahexaenoic acid (22:6n3; PC2 = 18%), compared with nestlings from Dundas WWTP, the rural site, and reference site. Glutathione and methionine metabolites are important for antioxidant defence and cellular regulation. Glutathione-related thiols differed between nestlings from the Brantford Landfill and Dundas WWTP along PC1 (38%), with variation driven primarily by glutathione. Methionine-related thiols differed between nestlings from the Brantford Landfill and the rural site (PC2 = 29%), with variation driven primarily by S-adenosylmethionine, a key metabolite in the methionine cycle. Collectively, these results suggest the potential for subtle changes in lipid and energy metabolism, fatty acids, and other physiological systems of nestlings near landfill and WWTP sites, possibly associated with PFAS

exposure.

Disclaimer/Disclosure: Natural Sciences and Engineering Research Council of Canada – Canada Graduate Research Scholarship-Master's (2026-2027).
Environment and Climate Change Canada (ECCC) – Chemicals Management Plan and Integrated Chemical Mixtures Project.
ECCC/McMaster University contribution agreement 2023-2027.

3.01.T-06 Potential Disruption of Total Triiodothyronine by Perfluorooctane Sulfonic Acid and Long-Chain Perfluorinated Carboxylates in an Arctic Seabird With Associations to Fitness and Reproduction

Emily Choy[1], Kyle Elliott[2], Ilse Esparza Magana[2], Allison Patterson[3], Robert Letcher[3] and Kim Fernie[3]
(1)McMaster University, (2)McGill University, (3)Environment and Climate Change Canada

Arctic climate change is occurring at an unprecedented rate and may cause challenges to avian thermoregulation and endocrine regulation. Seabirds are long-lived marine predators and sentinels of marine pollutants and ecosystem health. Through long-range transport, endocrine disrupting compounds such as perfluoroalkyl acids (PFAAs) have been detected in Arctic wildlife. There is evidence that PFAAs can lead to disruption of circulating thyroid hormones (THs), such as thyroxine (T4) and triiodothyronine (T3) in seabirds, which play important roles in metabolism, incubation, and thermoregulation. Here, we investigate the relationships between PFAAs and THs [total T4 (TT4), free T4 (FT4), total T3 (TT3) and free T3 (FT3)] in blood samples collected in 2016-2018 from 63 male and female thick-billed murres (Uria lomvia) at a colony located on Coats Island, Nunavut, in the central Canadian Arctic. PFUdA, PFOS, and PFTrDA were the dominant PFAAs in murre blood, accounting for approximately 77% of ∑PFAA. Females had higher PFAAs than males, possibly due to higher trophic feeding. We also examined the relationship between THs and PFAAs on fitness-associated reproductive traits, such as body mass and hatch dates. While FT3 and TT4 increased with several PFAAs, TT3 was negatively correlated with PFOS, PFDoA, PFTrDA, and PFTeDA in murres, suggesting thyroid disruption. Body mass was positively associated with TT3 concentrations in murres, whereas several PFAAs were negatively correlated with body mass, particularly PFDoA, PFTrDA, and PFTeDA. Higher TT3 concentrations were associated with later hatch dates in murres, whereas PFDoA and PFTeDA corresponded with earlier hatch dates. As an Arctic seabird experiencing several indirect effects of climate change, the interaction of PFAAs on thyroid activity may cause additional stress to murres.

Disclaimer/Disclosure: Northern Contaminants Program
NSERC PDF
Weston Family Award in Northern Research

Bidirectional Framework: Evaluating Exposure to Contaminants in Birds in Lab and Wildlife Studies

3.01.P-Th028 Toxic To Tame: Current Status of Toxic Chemicals in Herring Gull Eggs in

the Great Lakes

Shane de Solla[1], Karen Kidd[1], Kimberley Hughes[2], Doug Crump[3], Kim Williams[4] and Glenn Barrett[3] (1)McMaster University, (2)Broadwing Biological Consulting, (3)Environment and Climate Change Canada, (4)Environment and Climate Change Canada (retired)

Herring Gull (Larus argentatus) eggs have been used to monitor contaminants in the Laurentian Great Lakes since 1974. The status of the Great Lakes and connecting channels is assessed by integrating chemical concentrations and exceedances of wildlife protection thresholds. This is reported in the "Toxic Chemicals in Herring Gull Eggs" indicator as part of the binational State of the Great Lakes reporting process. This indicator is based upon the spatial and temporal trends of legacy contaminants (e.g., PCBs, DDT, dieldrin) in eggs from 15 Great Lakes herring gull colonies. Although legacy pollutants have declined significantly from the 1970s, recent contaminant trends from 2013–2023 show a marked stabilization. The mean percent declines per year varied from a maximum of 0.58% (Hg; 95% CI -5.4 to 4.5) to a minimum of -10% (Sum Chlordane; -18.9 to -0.05), of which only two compounds significantly declined. Concentrations of contaminants were below thresholds associated with reproductive impairment. A meta-analysis was used to determine if there was any impairment in the health of gulls from contaminated Great Lakes Areas of Concern (AOCs) relative to reference sites that may be associated with contaminants. Measures included clutch volume, hatching success, embryonic deformities, productivity, circulating thyroid hormones, T cell-dependent immune function, and corticosterone. The confidence intervals of the effect sizes of all measures included zero, indicating no evidence of impairment of the health of birds from AOCs. The productivity of all colonies exceeded values expected to maintain stable populations. Hence, every Great Lake was listed as "Unchanging", indicating slowed progress in reducing contaminant burdens, but the status of all lakes was assessed as "Good" for 2013–2023. Ongoing monitoring is essential to evaluate progress under the Great Lakes Water Quality Agreement, particularly for Chemicals of Mutual Concern, and emerging chemicals of concern.

3.01.P-Th029 Non-Lethal Blood Sampling Reveals Passerine Bird Exposure to Pesticides Used in Row-Crop Agriculture in Argentina's Pampa Region

Julie C. Brodeur[1], M. Belén Poliserpi[2], Claudia Santamaria Cervantes[3] and Ana Clara Caprile[2] (1)Conicet, (2)INTA, (3)Universidad Castilla La Mancha

Extensive row-crop agriculture predominates in Argentina's Pampa region. Although agricultural expansion is known to negatively affect Pampean bird communities, the potential role of pesticides in their population declines, and the presence of pesticide residues in the birds themselves, has remained unevaluated. This study assessed 40 pesticide residues in the blood of passerine birds from agricultural fields in the region and compared detection frequencies and concentrations with those in birds from a suburban setting. Forty-seven birds were captured in the agricultural zone, while 64 were sampled in the suburban sector. All birds were released after a quick blood draw. Sampled passerine species included rufous-collared sparrow, grayish baywing, shiny and screaming cowbirds, white-tipped and picui doves, rufous and creamy-bellied thrushes, rufous hornero, great kiskadee, campo flicker, and green-barred woodpecker, among others. Ninety-four percent of birds from agricultural fields presented one or more pesticide residues in their blood, compared to 64.1% in the suburban setting. A significantly greater number of pesticide residues was detected in the bloodstream of agricultural birds (median = 3, max = 7) than in suburban birds (median = 1, max = 5). Seven pesticide active ingredients were detected more frequently ($p \leq 0.05$) in birds from agricultural fields than in those from

suburban areas: atrazine (14 vs 0%), azoxystrobin (25.5 vs 3.1%), carbendazim (46.8 vs 4.7%), dinotefuran (21 vs 6%), imidacloprid (12.8 vs 0%), and pyraclostrobin (44.7 vs 6.3%). Other pesticides detected in birds included acetochlor, clethodim, chlorimuron, chlorantraniliprole, 2,4-D, metalaxyl-methyl and sulfentrazone. The detected pesticides are commonly used on the region's main crops, which include soybean, maize, and wheat. These findings reveal the actual toxic burden on individual birds in Pampa region agricultural fields and establish a foundation for assessing potential risks to entire bird communities.

3.01.P-Th030 Toxicokinetics and Toxicodynamics of UV-328 in Japanese Quail (Coturnix japonica) Embryos

Ramela Koumrouyan[1], Sarah Vivet[1], Doug Crump[2], Zhe Lu[3] and Jessica Head[1] (1)McGill University, (2)Environment and Climate Change Canada (ECCC), (3)University of Quebec at Rimouski (UQAR)

Ultraviolet absorbents (UVAs) are industrial chemicals widely used for their photoprotective properties. They are ubiquitous in the environment and have been detected in a variety of avian species, including colonial waterbirds and terrestrial species. Effects of UVAs have been explored across a variety of taxa, including plants, fishes, and mammals. There is limited evidence about their effect and biotransformation in birds, despite their frequent detection. The following study investigates the toxicokinetics and toxicodynamics of UV-328 in early-life stage Japanese quail (Coturnix japonica). UV-328 was injected into the air cell or yolk of fertile quail eggs and artificially incubated. On four distinct embryonic days (EDs), a sub-set of incubated embryos (n=4 on ED1 and three pools of 4 embryos each on ED6, ED9 and ED16) were euthanized, dissected, and different compartments (shell membrane, extraembryonic contents, embryo, and liver) were collected for UV-328 analysis. On the two latter embryonic days, changes in mortality, morphology (embryo and organ weights, tarsus length, head and bill length, observable deformities), and hepatic gene expression (using the EcoToxChip custom 384-well qPCR array) were assessed. Preliminary data from air-cell injection studies demonstrate that the bulk of UV-328 was detected in the shell membrane. Though less than 5% of injected UV-328 reached the embryo, and subsequently the liver, dysregulation of hepatic genes involved in lipid metabolism and endocrine regulation was observed. Continuing studies will explore whether yolk injection will enhance chemical distribution to the embryo and liver, resulting in an elevated morphological and molecular response. This research fills knowledge gaps on a compound of regulatory interest in underrepresented taxa. Furthermore, it may reveal the limitation of chemical exposure via air-cell injections, an alternative method used frequently in avian toxicology studies.

3.01.P-Th031 Endocrine, Immune, and Biochemical Responses of American Kestrel (Falco sparverius) Exposed to a Simulated AFFF Mixture

Natalie Karouna-Renier[1], Elizabeth Brandt[1], Sandra Schultz[2], Cara Masullo[2], David Haskins[3] and Andrew East[4] (1)U.S. Geological Survey (USGS), (2)US Geological Survey, (3)EA Engineering, Science, and Technology Inc. PBC, (4)University of Maryland College Park

Per- and Polyfluoroalkyl Substances (PFAS) are a vast class of manufactured, persistent chemicals that have garnered significant global concern. These chemicals have a variety of useful industrial and consumer applications including their use in non-stick cookware, clothing, and food-packaging, but also in aqueous film-forming foams (AFFFs). AFFFs have been used since the 1970s by the Department of Defense (DoD) for Class B fires on military installations, airports, and fire training facilities, and has led to widespread contamination of

water, soil, and sediment. Research has demonstrated that several PFAS, such as PFOS and PFOA, are linked to adverse effects in organisms and bioaccumulate in aquatic and terrestrial food chains. However, there is little information regarding the effects of PFAS mixtures and trophic transfer through the avian food web. Raptor species, such as the American kestrel (Falco sparverius), are geographically common and have a high trophic position in the food chain. Hence, exposure is possible through bioaccumulative/biomagnification and/or maternal transfer processes. In 2024, we exposed adult male and female American kestrels and their hatchlings to a simulated AFFF-relevant PFAS mixture containing PFOS, PFHxS, PFOA, and PFHxA via their primary diet (mice). This four-chemical mixture included the most frequently occurring PFAS in surface water and soil at AFFF impacted sites. Four dose groups were selected based on previously derived avian toxicity reference values (TRV) – control, 0.2 mg/kg-day, 1 mg/kg-day, and 5 mg/kg-day total PFAS. The goal of this study was to evaluate how PFAS mixtures travel up the avian food web, partition into different biological compartments, and transfer from mother to egg. In addition, this study examined the physiological effects of PFAS mixtures across American kestrel life stages by investigating potential immune modulation and thyroid hormone disruption. Here we present preliminary results for thyroid gland hormone levels for thyroxine (T4) and triiodothyronine (T3), and immune endpoints including hemolysis-hemagglutination and plasma biochemistry. Our data will provide an improved understanding of PFAS mixture effects and trophic transfer through avian food webs and will inform future ecological risk assessments and environmental remediation plans for AFFF-impacted sites.

Disclaimer/Disclosure: This information is preliminary and is subject to revision. The information is provided on the condition that neither the U.S. Geological Survey nor the U.S. Government shall be held liable for any damages resulting from the authorized or unauthorized use of the information.

3.01.P-Th032 Chlorate and Perchlorate Exposure in Urban Wildlife: Combining Bird-Borne GPS Telemetry and Passive Air Sampling To Assess Pathways in the Montreal-Breeding Ring-Billed Gull

Matilde Baranton[1], Pauline Bellot[1], Lounès Haroune[2], Raphaël Lavoie[3] and Jonathan Verreault[1] (1)University of Quebec in Montreal (UQAM), (2)University of Sherbrooke, (3)Environment and Climate Change Canada (ECCC)

Chlorates and perchlorate are oxychlorine chemicals exhibiting oxidizing and reactant properties that are used in a wide range of industrial (e.g., paper production, pyrotechnics) and agricultural (e.g., pesticides, fertilizers) applications. They were shown to elicit toxicity; chlorates can induce oxidative stress, and both were reported to have endocrine-disrupting properties. Despite their widespread use, the emission sources, exposure pathways, and toxicological impacts in wildlife species spanning agro-urban habitats remain poorly characterized. This study aimed to identify the sources and atmospheric pathways of exposure to chlorates and perchlorate in a wild bird by combining bird-borne Global Positioning System (GPS)-based telemetry and Passive Air Sampling (PAS). The ring-billed gull (Larus delawarensis) breeding in the densely populated Montreal area (QC, Canada) exploits a mosaic of highly urbanized and agricultural foraging habitats, making it an ideal sentinel species to address this objective. In 2025, 25 adult female and male gulls were equipped with miniature GPS dataloggers and PAS devices. After 10 days of tracking, gulls were recaptured, devices were retrieved, and feathers and plasma samples were collected. Gull movements within the Montreal area were segmented into distinct behavioral states using Hidden Markov Models. Results revealed that gulls spent most of their time at the

colony (58%), and while outside the colony they spent 20% foraging and 22% in flight (transit to/from foraging sites). Preliminary analyses showed that both chemicals were detected in more than 93% of PAS and more than 96% of feathers, suggesting widespread atmospheric exposure. In plasma, chlorates and perchlorate were detected in 59% and 17% of samples, respectively. No correlation was observed between chlorate and perchlorate concentrations in plasma, PAS or feathers, suggesting differences in emission sources or bioaccumulation dynamics. Analyses are ongoing to model the relationships between HMM-derived behavioral states, habitat use, and multi-matrix contaminant concentrations.

Cold-blooded in the Face of Pollution: Understanding and Mitigating Threats to Amphibians and Reptiles

3.02.T-01 Frequent, Persistent, and Hidden Harmful Algal Blooms in Amphibian Habitats Reveal a Need for Expanded Monitoring and Research

Brian Tornabene[1], Kelly Smalling[1], Chris Pearl[1] and Blake Hossack[1] (1)USGS

Harmful algal blooms (HABs) are increasing worldwide and pose an underrecognized risk to amphibians that occupy small, warm, nutrient-rich habitats where cyanotoxins can impair development, behavior, disease resistance, and survival of aquatic vertebrates. Drought can further intensify HABs by concentrating nutrients and reducing water volume, elevating risks of reproductive failure and population declines, especially in the western US. Nevertheless, HAB dynamics in amphibian habitats remain poorly understood, and remote sensing can miss the small, ephemeral, or canopy-covered sites amphibians occur in. To address these information gaps, we conducted multi-method, on-the-ground monitoring across 33 subsites in four western states (2024–2025) by first comparing enzyme-linked immunosorbent assays (ELISA), rapid test strips, and solid phase adsorption toxin tracking (SPATT). Rapid strips showed high agreement with ELISA for anatoxin and cylindrospermopsin (≥93%) and reliable agreement (72%) for microcystin that could be improved by using lower-detection-limit test strips. SPATT results were less useful because they were limited to detection/non-detection and integrated measures over weeks. Cyanotoxins were widespread (100% and 55% of sites in 2024 and 2025) and persisted for weeks to months (~50 d; 1–124 d). Microcystin dominated detections (~80%) and could reach concentrations known to be harmful to amphibians, including two events prompting human health advisories in Oregon and Idaho. Visual indicators proved unreliable because toxins were detected without visible bloom signs (~70% of occurrences), indicating that visual surveys and remote sensing may fail to detect HABs. One amphibian mortality event that coincided with a HAB was attributed to disease, highlighting potential interactions between disease and cyanotoxins. Expanded monitoring across the conterminous US using standardized, field-based sampling could help to better understand spatiotemporal patterns and risk to amphibians, as well as inform timely notifications to protect the health of humans, pets, livestock, and other wildlife.

3.02.T-02 Sequestration of per- and Polyfluoroalkyl Substances in the Brain, Blood, and Liver of Burmese Python

Jack Arnold[1], Melissa Miller[1], Ian Bartoszek[2], Jada Lewis[1] and John Bowden[1] (1)University of Florida, (2)Conservancy of Southwest Florida

Per- and polyfluoroalkyl substances (PFAS) accumulate in tissues over time and magnify across trophic levels. This trophic transfer explains why apex predators contain high levels of PFAS, making them reflective of their environment, positioning them as ideal sentinel species. Burmese Pythons (Python bivittaus) are a unique sentinel species of the Florida Everglades as they are relatively long lived, holophagous consumers, and habitat both water and land. These apex predators are also invasive species, making sample collection opportunistic while minimizing sampling of native species. In this project, we dissected 39 adult Burmese Python heads (19M and 20F), with care to the harvest the rostral and caudal regions of the brain, in addition to also collecting whole blood and liver tissue. These organs were extracted for PFAS using ion pair extraction and were analyzed for 68 PFAS using liquid chromatography-tandem mass spectrometry (LC-MS/MS). Across all tissues, 28 PFAS were detected, with 25 quantified. Knowledge of PFAS presence in brain tissue is more limited, especially in wild species, when compared to other organs, such as the liver or blood (which are the preferred tissues for testing). Interestingly, our results showed that the brain was higher in PFAS, in comparison to the liver and blood (in that order). This study marks the first detection of PFAS in reptilian brains, and the finding that the brain exhibited higher PFAS concentrations than the liver, a unique observation compared to all prior studies. Current knowledge suggests that the presence of PFAS follows similar patterns across brain tissue, with accumulation increasing alongside carbon chain length and presence of sulfonate groups but decreasing further away from blood flow. Our study reflected this observation, as the caudal region had significantly higher levels of PFAS compared to the rostral region. This indicates that distribution of PFAS across the brain is likely not species dependent, which offers great insight into future research regarding predicting the PFAS in key neuronal segments. These findings have implicit value for neurodegenerative research and provide insight into unique PFAS patterns of sequestration between brain regions, and subsequently other tissues. Key neurological diseases are often region specific, and highlighting the relationship of PFAS to brain compartments can provide a better understanding of the etiology of disease and disease progression.

3.02.T-03 Advances in Field-Based Investigations of Methylmercury in Amphibians

Brian Tornabene[1], Collin Eagles-Smith[1], Kelly Smalling[1] and Blake Hossack[1] (1)U.S. Geological Survey (USGS)

Amphibians face unprecedented global declines from many threats, including contaminants such as mercury (Hg) and other stressors. While the biphasic life history of many amphibians increases the risk of methylmercury (MeHg) exposure in aquatic habitats, variation in tissue concentrations across life stages and effects on animal health remain largely unknown, whether considering MeHg alone or in combination with other stressors like disease. We will summarize several recent studies that have quantified MeHg bioaccumulation across life stages (from embryos to adults), refined methods for non-lethal measurement of MeHg in larvae and adults, and estimated the effects of MeHg on survival of adult amphibians. Our results show that sampling tails (amphibian larvae, adult salamanders) or toes (adult frogs and toads) is an effective measure of whole-body MeHg concentrations. Sampling adults across the conterminous USA revealed a 33-fold difference in MeHg tissue concentrations across study sites. Based on multi-year capture-mark-recapture studies

at 10 of these sites (representing 7 species), we found evidence that MeHg reduces survival of adult frogs and toads and can act synergistically with Batrachochytrium dendrobatidis (Bd), the fungus that causes the lethal disease amphibian chytridiomycosis. Although effects varied among species and sites, our results provide the first evidence of MeHg reducing survival of wild, adult amphibians. Our results also help clarify the potential for direct and synergistic effects of MeHg and disease and highlight the large sample sizes required for confidently identifying the potential health effects of contaminants under field conditions. All post-embryo life stages for a broad suite of amphibian species can now be sampled non-lethally for MeHg, allowing for more intensive field sampling and broader examinations of population- and community-level effects, including for imperiled species that cannot be sampled destructively.

3.02.T-04 Use of Species-Specific Information To Better Inform an Endangered Species Assessment

Colleen Priest[1] and Dwayne Moore[2] (1)Corteva, (2)Stone Environmental

Endangered species assessments in the United States are typically conducted with generic data to conservatively quantify exposure. The US Environmental Protection Agency (EPA) relies on the Terrestrial Residue Exposure (T-REX) model to estimate potential exposure and risk to birds and mammals. In the absence of data, EPA uses the risk estimates for birds as surrogate for terrestrial-phase amphibians and reptiles. T-REX relies on generic food intake rates, as well as default diet and body weight categories. However, species-specific data are available to refine the T-REX estimates for endangered species assessments. Food intake rate is equal to field metabolic rate (FMR) divided by the combined metabolic energies of dietary items. FMR has been determined for numerous species and the current FMR dataset includes a wide range of taxonomies, habitats and diets. An updated literature search was conducted to compile available FMR data for birds, mammals, and reptiles. Allometric relationships were determined by the type of animal (bird, mammal, reptile), taxonomic order, habitat (e.g., desert, marine, mountain), and dietary preference. Overall, taxonomic order was the best predictor of FMR, except for species found in extreme environments where lower FMRs are common. Next, preferred habitats and diets for listed bird, mammal, and reptile species were compiled from open literature. Species-specific exposure estimates for endangered wildlife species were then calculated using the compiled FMR, habitat and diet information. These species-specific exposure estimates were compared to the default T-REX outputs to determine if T-REX under- or over-estimates exposure for endangered species. Although the screening-level information from T-REX has value as a coarse screen in the early stages of an endangered species assessment, use of refined data allows for a more informed assessment, particularly for terrestrial-phase amphibians and reptiles, to ensure that protections are applied where they are most effective. This presentation will explore the use of species-specific information for risk assessment, with a focus on reptiles.

3.02.T-05 Effects of Microplastics on the Growth and Development of American Toad Tadpoles in a Freshwater Lake Using an In-Situ Enclosure Experiment

Jihyun Kim[1], Jennifer Provencher[2], Diane Orihel[1], Barb Katzenback[3], Chelsea Rochman[4] and Emily McKenzie[3] (1)Queen's University, (2)Environment and Climate Change Canada (ECCC), (3)University of Waterloo, (4)University of Toronto

Microplastics have varied effects on aquatic organisms, but have been understudied in amphibians. As this body of literature expands, current research involving microplastics and amphibians is primarily from laboratory

studies, with a lack of more environmentally relevant experiments. Therefore, we aimed to examine American toad (Anaxyrus americanus) tadpole responses to microplastics as part of a whole-lake manipulation study by the pELAstic Project at the International Institute for Sustainable Development-Experimental Lakes Area. Every summer for three years, this manipulation study involved loading a natural boreal lake with a mix of microplastic polymers (polyethylene, polystyrene, and polyethylene terephthalate) at an environmentally relevant concentration based on urban stormwater runoff. For each of the three years of microplastic loading, we collected wild American toad larvae and reared them in flow-through in-situ enclosures within the microplastic-loaded lake and a reference lake. As they developed, we sampled the tadpoles from the two lakes to quantitatively compare growth and developmental timing. The tadpoles reared in the microplastic-loaded lake were also sampled for microplastic body burden. In the microplastic-loaded lake, we found tadpoles at metamorphic climax from the third year of microplastic loading (2025) had an average microplastic body burden of 20.46 particles/individual (1.53 particles/mg of dry weight). Preliminary analysis of the growth endpoints found a similar trend for all three years where overall, tadpoles from the microplastic-loaded lake had shorter body (snout to vent) lengths ($p=0.0003$) and slightly lower body weights ($p=0.002$) at metamorphic climax in comparison to those from the reference lake. Further analysis will include examining other variables such as temperature to determine potential lake effects, and primary productivity to better understand the direct and indirect effects of microplastics on the tadpoles. This presentation will provide final results for microplastic body burden and the comprehensive analysis of microplastic effects on the growth and developmental endpoints, over all three years of the experiment. Altogether, this study contributes novel insight into how amphibian larval growth and development can respond to microplastics under natural conditions, bridging laboratory studies with the real world to better inform management policies and regulations.

3.02.T-06 Accumulation and Potential Effects of per- and Polyfluoroalkyl Substances (PFAS) in the Diamondback Terrapin (Malaclemys terrapin) Along the Atlantic Coast

David Lee Haskins[1], Willem Roosenburg[2], Christopher Rowe[3], Amanda Williard[4], Robert Burke[5], John Wnek[6], Scott Smith[7], Zachary Hopkins[8], Andrea Tokranov[8] and Natalie Karouna-Renier[8] (1)EA Engineering, Science, and Technology Inc. PBC, (2)Department of Biological Sciences, Ohio University, Athens, OH, (3)University of Maryland Center for Environmental Science, Solomons, MD, (4)Department of Biology and Marine Biology, University of North Carolina Wilmington, Wilmington, NC, (5)Department of Biology, Hofstra University, New York, NY, (6)Marine Academy of Technology and Environmental Science, Stafford Township, NJ, (7)Maryland Department of Natural Resources, Wye Mills, MD, (8)U.S. Geological Survey (USGS)

Per- and polyfluoroalkyl substances (PFAS) are a widely used group of chemicals that are of global concern due to their persistence and accumulation in humans and wildlife. Internationally, there is a paucity of data related to PFAS exposure and effects in reptiles. Reptiles are important components of natural ecosystems and can serve as effective bioindicators of contamination. Similar to other aquatic turtles, diamondback terrapins (Malaclemys terrapin) may be useful for monitoring various pollutants in estuarine habitats. Terrapins exhibit many characteristics that make them ideal for assessing PFAS contamination, including a long-life span, moderate home ranges, and a relatively high trophic position. Because terrapins generally consume crustaceans and mollusks, and dietary preferences may vary by region, non-lethal blood sampling could provide an effective matrix for identifying potential exposure risk and negative health outcomes in this vulnerable species. To better understand bioaccumulation of PFAS and potential physiological effects, we collected blood samples from terrapins throughout waters along the Atlantic coast in New York, New Jersey, Delaware, Maryland, and North

Carolina. Plasma was analyzed for PFAS compounds using HRMS-LC and indicators of immune status and metabolic and organ health. The results indicate variations in PFAS bioaccumulation and profiles across the sampling locations. Further analyses will investigate potential associations between PFAS and select health biomarkers. These novel ecotoxicological and health data provide a foundation for understanding PFAS exposure in these systems, as well as identifying factors that may dictate exposure risk and will assist state natural resource and wildlife agencies with management of terrapin populations.

Cold-blooded in the Face of Pollution: Understanding and Mitigating Threats to Amphibians and Reptiles

3.02.P-We032 PFAS in an Endangered Turtle, Part 1: Aquatic Exposure and Bioaccumulation in Blood

Dianne Kopec[1], Jitka Becanova[2], Fabian Fischer[2], Simon Vojta[2], Kara SantaLucia[1] and Matthew Chatfield[1] (1)University of Maine, (2)University of Rhode Island

Per- and polyfluoroalkyl substances (PFAS) are a group of ubiquitous synthetic chemicals that pose significant risks to both wildlife and humans. PFAS toxicity includes immunological and reproductive consequences that are of particular concern to sensitive species like the wood turtle (Glyptemys insculpta), which is declining throughout its range in the United States and Canada. Wood turtles exhibit seasonal movement between aquatic overwintering habitats and terrestrial summer foraging habitats. Aquatic respiration through the cloaca and other highly vascularized tissues allows for dermal absorption of available contaminants from the sediment and water column during their five-month brumation. Stream transects within the research site of our long-term wood turtle tracking study encompassed a gradient of PFAS contamination from agricultural sources. In order to assess the turtles' exposure to and bioaccumulation of PFAS, 40 blood samples were collected from 21 individual turtles over three seasons: early spring, summer, and late autumn. Heparin plasma samples were analyzed for 56 targeted PFAS. Albumin concentrations were used to assess PFAS binding to blood proteins. In turtle plasma, eight PFAS were detected in the majority of samples and fitted to a left-censored linear mixed effects model. Blood PFAS was regressed against albumin, transect, sex, and season. Significant positive slopes were found for most PFAS for albumin, individual sites, and the spring sampling season. Males had significantly greater PFAS concentrations than females. Both stream water and sediment PFAS concentrations show a decline in the upstream to downstream transects over the ~10km site. Our findings suggest significant PFAS exposure during the winter brumation in wood turtles.

3.02.P-We033 Effects of Heavy Metals and Organic Contaminants in Juvenile and Adult C. Morelettii in Various Waterways in Belize

Andrea Torzone[1], Marisa Tellez[2], Theresa Guillette[3] and Matthew Guillette[4] (1)Michigan State University, (2)Crocodile Research Coalition, (3)Arcadis, (4)BST Consulting, LLC

Aquatic pollution from heavy metals and chemical contaminants poses a growing threat to ecosystem stability and wildlife health worldwide. In Belize, waterways such as the New River Lagoon have experienced eutrophication, elevated temperatures, and accumulation of toxic metals including lead, mercury, and arsenic. As apex predators and long-lived sentinel species, Morelet’s crocodiles (Crocodylus moreletii) provide a

valuable model for assessing contaminant impacts within a One Health framework.
From July to August 2025, 43 juvenile and adult crocodiles were captured during nocturnal surveys across six sites in Belize (Crooked Tree, New River Lagoon, Monkey River, Sittee River, Habanero Lagoon, and Placencia Lagoon). Individuals were measured, body condition scored and sampled for blood and osteoderm scutes before release. Blood smears and field hematology provided immediate health indicators, while scutes and other bloodwork will be analyzed for long-term heavy metal accumulation. Pending laboratory analyses include blood chemistry panels, oxidative stress assays, leukocyte differentials, and contaminant screening to evaluate immune function, organ health, and sublethal physiological stress.
Preliminary field data reveal site-specific differences in crocodile health. Individuals from the New River Lagoon exhibited significantly lower body condition indices ($p = 0.003$), reduced packed cell volume, and irregular protein and lactate values compared to crocodiles from less impacted systems. Juveniles showed lower Brix values, suggesting compromised nutritional or physiological status. Visual assessments also noted higher frequencies of emaciation and tissue abnormalities in this system. Additionally, morphometric measurements indicate a trend toward reduced total phallus length in males from the New River Lagoon relative to other sites, warranting further investigation of potential contaminant-related endocrine effects.
Together, these findings suggest that chronic pollution exposure may already be impairing immune function and overall health in crocodile populations inhabiting degraded habitats. Ongoing laboratory assays will clarify mechanistic links between contaminant loads and physiological stress. This work highlights crocodilians as effective bioindicators and supports targeted pollution mitigation and conservation strategies to protect both ecosystem and human health in Belize.

Disclaimer/Disclosure: Funding: IUCN SSC Crocodile Specialist Group SRAS Grant and Boettcher's Fund Grant
** This is an ongoing project and some analyses are pending

3.02.P-We034 Characterizing the Toxicity of Sulfolane to Different Life Stages of the American Toad (Anaxyrus americanus)

Amanda Reside[1], Frédéric Laberge[1] and Ryan Prosser[1] (1)University of Guelph

Sulfolane is a chemical used in many industrial processes, notably in the refinement (or “sweetening”) of sour natural gas before the gas is sold as fuel. Sulfolane has been detected in ground water at industrial sites in Canada. It is a contaminant of potential concern due to its high solubility and mobility potential in water (LogKoc ~0-0.1). Groundwater contaminants can enter surface water via springs and seeps, posing questions regarding their toxicity to aquatic organisms. This study aims to characterize adverse effects of sulfolane exposure during the aquatic life stage of amphibians. Specifically, we investigate critical windows for toxicity by performing three separate, acute exposures during embryonic, early larval, and late larval development of American toads (Anaxyrus americanus). Toad egg strings were collected from a pond in Guelph, ON and transferred to static-renewal tanks in the laboratory. Each experiment consisted of a single 48h exposure to one of five sulfolane concentrations (0.1, 1, 10, 100, or 1000 mg/L) or control. The exposures occured at Gosner Stage (GS) #7 (32 cells), GS #25 (hatched, free feeding), or GS #31-35 (early foot development). After exposure, the animals were returned to clean water, then euthanized and sampled either at GS 42 (emergence of the forelimbs; embryonic and early larval experiments) or as post-metamorphic juveniles (late larval experiment). Here, we report mortality, body size, and developmental rate. Additionally, record locomotor

activity and thigmotaxis after exposure to capture potential effects on behaviour. These data are needed to support risk assessments of sulfolane for amphibians and develop environmental quality guidelines.

Disclaimer/Disclosure: Disclaimer: specific results are not reported in the abstract because experiments are ongoing at the time of submission and will conclude in July 2026. The described endpoints will be presented in full at the conference.

This project is funded via NSERC Alliance.

3.02.P-We035 Elevated Mercury and Arsenic Concentrations in Frogs Inhabiting Wetlands Contaminated by Legacy Gold Mine Tailings in Nova Scotia, Canada

Samuel A. Sequeira[1], Bradley Knockwood[1], Gregory F.M. Jongsma[2], Donald F. McAlpine[2] and Linda Campbell[1] (1)Saint Mary's University, (2)New Brunswick Museum

Wetlands in Nova Scotia (NS) have been contaminated by legacy gold mine tailings containing amalgamation mercury (Hg) and geogenic arsenic (As). These toxic elements have persisted in these ecosystems, bioaccumulating in organisms and transferring through aquatic food webs. Amphibians are particularly susceptible to contaminants due to their physiology and ecology, including wetland habitat preferences, trophic position, and highly permeable skin. Despite this vulnerability, amphibians at contaminated sites in NS have remained largely unassessed. The aim of this study was to quantify Hg and As concentrations in wild frogs inhabiting wetlands contaminated by historical gold mine tailings in Nova Scotia. During 2024–2025, we sampled frogs inhabiting tailings-impacted wetlands within three historical gold mining districts and analysed their leg muscles for total Hg and As concentrations. Bayesian hierarchical models were used to assess differences in tissue contaminant concentrations between species and sites. Adult green frogs (Lithobates clamitans) at contaminated sites had over 40% higher Hg (0.43 ± 0.22 mg/kg vs 0.31 ± 0.11 mg/kg) and 20-fold higher As (5.41 ± 6.16 mg/kg vs 0.27 ± 0.21 mg/kg) concentrations compared to individuals from reference sites. Aquatic frogs consistently showed higher contaminant burdens relative to sympatric terrestrial species. Because frogs occupy intermediate trophic positions and are prey for numerous vertebrates, elevated Hg and As in amphibians present a risk for trophic transfer within freshwater food webs. Given their widespread presence at tailings sites and high ecological sensitivity, green frogs show strong potential as biomonitoring species for assessing risks to freshwater vertebrates. These findings demonstrate that legacy gold mine tailings continue to influence contaminant exposure in amphibians and highlight the importance of considering amphibians in ecological risk assessments of contaminated wetlands.

3.02.P-We036 Concentrations of Mercury and per- and Polyfluoroalkyl Substances in the Spotted Turtle (Clemmys guttata): Assessing the Impacts of Multiple Stressors in Coastal and Inland Populations

David Lee Haskins[1], Xiaoyu Xu[2], Elizabeth LaBone[3], Emily Asche[2], Aaron Johnson[2], June Ekechukwu[2], Emily LePrell[2] and Tracey Tuberville[2] (1)EA Engineering, Science, and Technology Inc. PBC, (2)University of Georgia's Savannah River Ecology Laboratory, (3)Savannah River National Laboratory

The spotted turtle (Clemmys guttata) is considered a Species of Greatest Conservation Need in every state in which it occurs and is designated as a mission-sensitive species by U.S. Department of Defense (DoD) because

it occurs on at least 40 military installations and potentially another 48. Spotted turtles are exposed to a variety of stressors, including anthropogenic contaminants, varying hydroperiods (e.g., wetland loss), roads, saltwater intrusion from major storm events, and poaching. Our project aims to promote the resilience of spotted turtle stressors on military installations. Mercury (Hg) and per- and polyfluoroalkyl substances (PFAS) are contaminants of concern that bioaccumulate in wildlife and may elicit a variety of impacts across taxa, including reptiles. Spotted turtles possess many traits that may make them susceptible to the bioaccumulation of contaminants in aquatic environments. These turtles are long-lived, have relatively small home ranges, and are important predators of aquatic invertebrates within their respective wetlands. In 2025 and 2026, we sampled spotted turtles at six installations across South Carolina, Virginia, and Maryland. For this presentation, we will compare Hg and PFAS concentrations collected from spotted turtles among all locations. Our objectives are to (1) quantify total mercury (THg) and select PFAS compounds in turtle blood and plasma, (2) quantify PFAS in relevant abiotic matrices (e.g., water and sediment), and (3) compare turtle THg and PFAS concentrations among life stages and sampling locations. Our dataset presents a unique opportunity to provide critical Hg and PFAS bioaccumulation data for a reptile species recently considered for federal listing. In addition to providing baseline contaminant data for future monitoring efforts and risk assessments, our work will quantify stressors at each site and identify which stressors the turtles are most sensitive to, helping prioritize management actions and best management practices for the species.

3.02.P-We038 A Legacy Before Hatching: Evidence of Pre-Hatching Eggs Exposure to per- and Polyfluoroalkyl Substances in American Alligator (Alligator mississippiensis)

Cadance Swearingen[1], Lauren Blackman[1], Qaim Mehdi[1] and John Bowden[1] (1)University of Florida

Per- and polyfluoroalkyl substances (PFAS) are ubiquitous and pervasive “forever chemicals” that have been shown to bioaccumulate in food webs. However, the impact of PFAS exposure during early developmental stages remains largely understudied in oviparous wildlife. The American alligator (Alligator mississippiensis) is a long-lived, apex predator, with an expanding list of earlier studies focused on determining PFAS burdens in adult populations. Taking advantage of their egg-laying reproductive nature, this study aimed to characterize and quantify PFAS in alligator eggs collected from Florida (USA) across four complementary cohorts: (i) a geospatial comparison among three Florida water systems: Lake Woodruff, Lake Apopka, and Merritt Island National Wildlife Refuge (MINWR); (ii) a longitudinal analysis of Lake Apopka eggs collected between 1997–2016; (iii) a full-clutch stratification assessing within-nest variability; and (iv) a compartmental analysis of Lake Apopka eggs, investigating differences among paired yolk, chorioallantoic membranes (CAM), and embryos. Overall, 66 PFAS were monitored across these four complementary aims, with 37 PFAS quantified in the samples analyzed. PFAS were detected across all cohorts and individuals, with the highest individual egg, a sample from MINWR, $\sum$PFAS = 7946 ng g^{-1} hallmarked by the dominating presence of long-chain legacy PFAS, specifically linear PFOS, which was detected in 100% of samples analyzed. Clutch and paired tissue analysis hints at possible evidence of maternal transfer of PFAS, with PFAS distributed into different compartments within the developing embryo. This work tackles existing gaps in studying the fate of PFAS in oviparous species and highlights new directions aimed at better characterizing the impact of PFAS on development.

General: Wildlife Toxicology, Ecology and Stress Response

3.03.P-Tu041 An Epigenetic Clock To Estimate the Age of St. Lawrence Estuary Belugas and Its Relationship With Contaminant Accumulation, Stress, and the Health Status of This Endangered Population

Romain Thibault[1], Brianna Perino[2], Stéphane Lair[3], Magali Houde[4], Maikel Rosabal[1], Lounès Haroune[5], Hui Peng[6], Robert Michaud[7], Véronique Lesage[8], Krishna Das[9], Alice Dennis[10], Justine Belik[2], Lisa Loseto[11], Frédéric Silvestre[2] and Jonathan Verreault[12] (1)Center for Environmental Toxicology and Health (TOXEN), Département des Sciences Biologiques, Université du Québec à Montréal, Montreal, QC, Canada, (2)Laboratory of Evolutionary and Adaptive Physiology, Department of Biology, Université de Namur, Namur, Belgium, (3)Canadian Wildlife Health Cooperative, Département de sciences Clinique, Faculté de médecine vétérinaire[SL1.1], Université de Montréal, Saint-Hyacinthe, QC, Canada, (4)Environment and Climate Change Canada, Montreal, QC, Canada, (5)Institut de pharmacologie de Sherbrooke, Université de Sherbrooke, Sherbrooke, Canada, (6)University of Toronto, (7)Group for Research and Education on Marine Mammals (GREMM), Tadoussac, QC, Canada, (8)Fisheries and Oceans Canada, Mont-Joli, QC, Canada, (9)University of Liège, (10)Research Unit in Environmental and Evolutionary Biology, Department of Biology, Université de Namur, Namur, Belgium, (11)Fisheries and Oceans Canada, Sidney, BC, Canada, (12)University of Quebec in Montreal (UQAM)

Despite numerous protective measures, the endangered St. Lawrence Estuary (SLE) beluga population has failed to recover. An increase in mortality among females and newborns, combined with chronic exposure to environmental contaminants and other stressors, raises serious concerns regarding the health of this population. However, the lack of reliable age data for free-ranging belugas represents a significant challenge when assessing their health status, particularly in relation to contaminant exposure. To address this knowledge gap, this project will contribute to the development of an epigenetic clock to estimate both the chronological age (years since birth) and biological age (physiological state of aging) of SLE belugas. Epigenetic age is estimated by measuring DNA methylation at specific loci in the genome. The resulting "clock" is built using a penalized regression to select the subset of methylation sites that optimizes age prediction accuracy. Once validated, the clock will be implemented in an automated workflow to directly process DNA methylation from skin tissue, enabling rapid and efficient age estimation. This non-lethal and minimally invasive approach not only determines age but also detects accelerated or delayed biological aging that may be associated with contaminant exposure. Our objective will then be to characterize associations between age and tissue concentrations of flame retardants, per- and polyfluoroalkyl substances (PFAS) and trace elements, non-targeted transcriptomic biomarkers, endocrine markers (thyroid hormones and cortisol), and lipid markers (fatty acids, acylcarnitines, endocannabinoids, lysophosphatidylcholines, phosphatidylcholines, and sphingomyelins), as well as a body condition proxy and causes of mortality. Integrating these approaches will provide a better understanding of how age shapes contaminant exposure, stress, and the overall health of SLE belugas, and how environmental stressors can, in turn, influence biological aging. These data will thus offer essential support for management and conservation measures aimed at the recovery of this endangered population.

3.03.P-Tu042 The Extent of Plastic and per- and Polyfluoroalkyl Substance Contamination in Antarctic and Sub-Antarctic Wildlife

Madi McLatchie[1], Benjamin Viola[2], Cherie Motti[3], Gwilym Price[4] and Kevin Thomas[5] (1)Queensland Alliance for Environmental Health Sciences, University of Queensland, (2)Institute for Marine and Antarctic Studies,

University of Tasmania, (3)Australian Institute of Marine Science, (4)Department of Climate Change, Energy, the Environment and Water (DCCEEW), (5)University of Queensland

Anthropogenic pollution has reached wildlife breeding in the most isolated regions of the world, including the Antarctic and Sub-Antarctic. Extensive field campaigns have shown the impact pollution has had on biodiversity in Antarctic regions, including plastics and per- and polyfluoroalkyl substances (PFAS). Here, we aim to investigate the prevalence of plastic and PFAS contaminants in Antarctic wildlife by quantifying the output of relevant scientific literature and identifying and synthesising key knowledge gaps in this niche area. To meet our objective, we synthesised results from peer-reviewed articles focusing on plastics and PFAS in pinnipeds, seabirds, and cetaceans inhabiting Antarctica and sub-Antarctic regions. A total of 4,777 papers were sourced using Web of Science, Scopus, and GreenFILE, and after screening titles and abstracts, this number was reduced to 40 articles. Information including focal species, study location, sample types, and contaminant measurements were extracted and analysed in R. Most studies were conducted across the sub-Antarctic, and in the Antarctic, most studies focussed in the western region, including along the peninsula and at Atka Bay, with few reporting in the East Antarctic. The most studied species was the Adélie penguin with □PFAS concentrations ranging from 0.99-7.35 ng/g ww, while plastic counts ranged from 0.15 - 3.8 items/individual. The highest average count of plastics was 46.7 items/individual in brown skuas from South Georgia, and the lowest, 0.078 items/individual, in Macquarie Island cormorants. The highest mean □PFAS concentration was 16 ng/g ww in fur seals from the West Antarctic Peninsula, and lowest 0.24 ng/g ww in common diving petrels from South Georgia. Overall, these findings highlight clear geographic and taxonomic biases in the existing literature, as well as the limited number of studies available, underscoring critical knowledge gaps in this field. While research in the field is increasing, further studies are required to determine baseline contamination for species residing close to Antarctic stations compared to those distally isolated, and what impacts plastics and PFAS may have in tissues once they spread from the gastrointestinal tract to organs. Understanding pollution sources from local Antarctic research stations will assist in informing management outcomes contributing to conservation of wildlife species, including decision-making on in situ retention of abandoned infrastructure.

3.03.P-Tu043 Toxicity of Conventional, Renewable, and Blended Diesel Fuels to the Earthworm Eisenia fetida: Implications for Ecological Risk Assessment Following Terrestrial Fuel Spills

Peter Arth[1], Barbara Orelo[1], Katie Payne[1], Kasey Skrivseth[1], April DeSilva, Ph.D.[2], Cerasela Gadberry[2], Sao Uch[2] and Joseph Lacalle[2] (1)Nautilus Environmental, Inc., (2)CDFW-OSPR

The increasing adoption of renewable diesel fuels presents a need for ecotoxicological data to support environmental risk assessments and clean up thresholds following accidental releases to terrestrial environments. While toxicity information is available for conventional diesel fuels, comparatively little is known about the potential ecological effects of renewable diesel products and renewable-conventional diesel blends. To address this data gap, a testing program was initiated to evaluate the toxicity of representative diesel fuel formulations to terrestrial organisms.

A 14-day soil toxicity study was conducted using the earthworm E. fetida, a keystone invertebrate test species. Four fuel formulations were evaluated: conventional diesel, pure renewable diesel, and two renewable-conventional diesel blends. Fuel samples were incorporated into artificial soil, and range-finding tests were first performed to identify broad effect levels and establish concentration ranges for definitive testing. Definitive

tests consisted of five exposure concentrations per fuel type and assessed survival and retained biomass endpoints.
Concentration-response relationships were generated for each fuel formulation to derive no-observed-effect concentrations, lowest-observed-effect concentrations, and median lethal/effect concentrations. To support exposure characterization and interpretation of biological responses, soil samples from the test exposures were collected at initiation and termination for analytical verification of fuel concentrations.
Results demonstrated that renewable diesel and renewable diesel blends exhibited little to no toxicity to earthworms, with no significant effects on survival observed and only minor effects on biomass retention or behavior at the highest test concentrations. In contrast, conventional diesel caused reductions in survival and biomass retention, as well as observable behavioral effects, at substantially lower concentrations, indicating greater toxicity under the test conditions.
This study provides a direct comparison of the toxicity of diesel fuels to a representative soil-dwelling invertebrate and highlights that generating baseline data using laboratory-based ecotoxicity exposures is critical for characterizing new or emerging contaminants. The resulting data will contribute to improved ecological risk assessments for terrestrial fuel spills and support spill response and natural resource management decisions.

3.03.P-Tu044 Evaluating Developmental and Transcriptomic Responses to PFBA Exposure in Grass Shrimp (Palaemon pugio)

Eguono Omagamre[1] and Michella Salvitti[1] (1)University of Maryland Eastern Shore

Perfluorobutanoic acid (PFBA) is a short-chain per- and polyfluoroalkyl substance (PFAS) increasingly detected in aquatic environments due to its high environmental mobility and widespread use. While short-chain PFAS are often considered less bioaccumulative than their long-chain counterparts, growing evidence suggests they may still induce sublethal biological effects at environmentally relevant concentrations. However, little is known about the developmental consequences of PFBA exposure in estuarine invertebrates, particularly during sensitive early life stages.
This study will investigate whether PFBA exposure alters developmental progression in the estuarine grass shrimp (Palaemon pugio), an ecologically important species that serves as a key prey item within coastal food webs. Newly hatched larvae will be exposed to a gradient of environmentally relevant and elevated PFBA concentrations immediately following hatch and monitored through postlarval emergence. Primary endpoints will include time to postlarval emergence, while secondary endpoints will include survival, developmental stage progression, molt frequency, growth, morphological abnormalities, and swimming behavior. To provide mechanistic insight into observed phenotypic responses, transcriptomic analyses will be conducted at 24 hours post-exposure and again during late larval development prior to widespread postlarval emergence.
Unlike traditional toxicity studies that focus primarily on mortality, this project examines whether chronic low-dose PFBA exposure can alter developmental timing and larval progression. Shifts in developmental schedules may influence predator exposure, dispersal, recruitment success, and energy allocation, potentially producing ecological consequences even in the absence of overt toxicity. By integrating developmental phenotyping with transcriptomic analyses, this study will provide one of the first assessments of PFBA-associated developmental responses in an estuarine crustacean and help identify molecular pathways linked to altered developmental trajectories. Results will contribute to a growing understanding of the ecological risks associated with short-chain PFAS and inform future assessments of contaminant impacts on coastal ecosystems. Results are forthcoming.

Knowledge Gaps, Research Needs and Ecological Considerations to Improve Avian Exposure Assessments

3.04.P-We305 Setting the Stage: Knowledge Gaps, Research Needs and Ecological Considerations in Exposure Assessments

Mark Johnson[1], Adriana C. Bejarano[2], Barnett Rattner[3] and Philip Goodrum[4] (1)Old Dominion University, (2)ExxonMobil Biomedical Sciences, Inc., (3)U.S. Geological Survey (USGS), (4)GSI Environmental

Avian species possess distinct morphological, physiological, and ecological traits that set them apart from other vertebrates, yet current chemical exposure assessments rarely capture this complexity. Standardized frameworks often rely on generalized assumptions regarding behavior, diet and habitat use of common test species (quail, mallard), overlooking how factors such as habitat availability, life stage, ecological niche and species-specific biology influence exposure pathways and toxicological responses. Consequently, uncertainty in modeled exposure estimates, as well as discrepancies between model predictions and field observations, can lead to potential mischaracterization of risk.

This presentation will set the stage for the session by examining the state of the science in avian chemical exposure and effects assessment, and highlighting ongoing efforts to improve existing models and frameworks. It will explore how advances in incorporating biological and ecological traits, as well as accounting for physiological and behavioral plasticity, can improve representation of exposure pathways and internal dose. At the same time, it will consider current challenges associated with integrating complex life histories, foraging strategies and habitat preferences into assessment approaches, estimation of uncertainty and decision-making.

Several key questions will guide the discussion: What are the most influential avian traits driving variability in exposure and response? Where do current models diverge from empirical observations, and what explains these gaps? How can ecological data and trait-based approaches be better integrated into predictive frameworks without sacrificing usability? By addressing these and related questions, this presentation aims to highlight critical opportunities to advance next-generation exposure models that more accurately reflect avian diversity and improve ecological risk assessments.

3.04.P-We306 Predicting Bioavailability of Soil Pb to Birds by Incorporating Diet Into a New In Vitro Gastrointestinal Assay

Mason Reid[1] and Nicholas Basta[1] (1)Ohio State University

When bioavailability data is not available for a chemical, it is often assumed to be 100% bioavailable, though many common contaminants of concern are in reality much less bioavailable. Overly conservative estimates of 100% bioavailability can thus result in overestimation of risk as well as unnecessarily cost- and time-intensive cleanups. Experimentally determining bioavailability directly is also unappealing as it necessitates in vivo studies which likewise raise cost and time concerns in addition to ethical ones. We present a novel in vitro simulated gut digestion method that can be used to accurately predict relative bioavailability of soil lead (Pb) to birds. When diet is included in the novel in vitro method, in vivo-in vitro correlations were strong ($r2 = 0.92$), making the method the first simulated avian gut extraction shown to predict bioavailabilty of soil Pb to birds. When examining nutrient content among six different avian diets, the in vitro bioaccessible Pb was strongly

correlated with total phosphorus content (r2 = 0.78). By including a representative diet sample in the in vitro assay, relative bioaccessible Pb can be accurately estimated while avoiding the need for animal experimentation or diet-specific adjustments for toxicity calculations. This relative bioaccessible Pb estimation can be used in ecological risk assessment to yield more true-to-life estimated exposure doses for comparison to avian toxicity reference values. The adoption of this approach can help circumvent the challenges posed by overly strict ecological soil screening levels and overestimation of Pb availability and toxicity.

3.04.P-We307 Tissue-Based Exposure and Effects of Lead to Birds

Bradley Sample[1] (1)Ecological Risk Inc.

Delta-aminolevulinic acid dehydratase (ALAD), a lead-binding protein found in birds, helps regulate the bioavailability of lead and mediate its toxicity. ALAD, which is inhibited by lead exposure, is necessary for heme synthesis and is a major transporter of lead in blood. Inactivation of ALAD has been implicated in lead poisoning in birds. Beyer et al. (1988) exposed songbirds to gradually increasing doses of lead until 50% mortality occurred. Median ALAD inhibition among survivors was 81% to 95%. ALAD inhibition of 50% is also listed under US NRDA regulations as an indicator of physiological injury. Tissue lead concentration thresholds associated with ALAD inhibition are poorly documented. To address this, field and laboratory data on avian blood and liver concentrations, and ALAD activity, plus behavior, growth, and survival were extracted from published literature. Exposure-response relationships were derived using the USEPA Toxicity Relationship Analysis Program (TRAP) to relate blood and liver lead to ALAD inhibition, growth and survival. Tissue-based effect thresholds (EC10, EC20, and EC50) were developed by individual study, by data from more than one study grouped by species, or for data from multiple studies combined for more than one species. ALAD inhibition was most sensitive to lead exposure, followed by growth and mortality, regardless of tissue considered. EC20 ranges for blood were 0.4 to 1.4 mg/kg dw, 15.9 to 16.1 mg/kg dw, and 21.6 to 55.5 mg/kg dw for ALAD inhibition, growth, and mortality, respectively. In liver, EC20 ranges were 0.5-15.5 mg/kg dw, 6.2 to 28.4 mg/kg dw, and 37.4 to 109.2 mg/kg dw for ALAD inhibition, growth, and mortality, respectively. Based on an extensive review of tissue lead versus effects, Franson and Pain (2011) identified ranges in blood and liver of waterfowl and raptors associated with subclinical, clinical, and severe clinical effects. Tissue lead concentrations below subclinical were considered to be indicative of background. All dose-response thresholds for growth and mortality based on blood lead and 75% of growth and mortality thresholds based on liver lead fell within the severe clinical range. In contrast, dose-response thresholds for ALAD inhibition associated with blood lead fell predominantly in the background (for EC10 thresholds) or subclinical (for EC20 and EC50) ranges. A similar pattern was also observed for ALAD inhibition associated with liver lead.

3.04.P-We308 Evaluating the Risk to Forest Birds of Systemic Insecticides Used for the Control of Hemlock Woolly Adelgid (Adelges tsugae) in Southwest Nova Scotia

Catherine Potvin[1], Margaret L. Eng[2], Christopher Edge[3] and N. Kirk Hillier[1] (1)Biology Department, Acadia University, (2)Science and Technology Branch, Environment and Climate Change Canada, (3)Canadian Forest Service Department, Natural Resources Canada

Systemic neonicotinoid insecticides are currently being applied under emergency provisions to manage hemlock woolly adelgid (Adelges tsugae; HWA) infestations in Nova Scotia, Canada. However, the risks to birds under these operational forest management scenarios remain largely unquantified. Hemlock woolly adelgid-induced

mortality is driving widespread decline of eastern hemlock (Tsuga canadensis), a foundational species of the Wabana'ki-Acadian Forest, altering forest structure and threatening the hemlock-associated bird community. While chemical control can prevent tree mortality, it may also expose birds to direct toxicity and reduce insect prey availability, creating potential ecological risks that have not been adequately assessed in applied management contexts. This study assessed the risk of exposure to imidacloprid (IMI) and dinotefuran (DINO) neonicotinoids by forest birds through the ingestion of putative prey items in southwest Nova Scotia. To evaluate insecticide exposure, we quantified pesticide concentrations in food items belonging to different foraging guilds (canopy gleaners, sap feeders, and ground foragers), and used stable isotope mixing models to estimate food type proportions contributing to daily food intake. We characterized toxicity risk by comparing modelled exposure to effect thresholds. We validated predicted exposure models by comparing detection rates of IMI and DINO in the blood plasma of targeted bird species under three treatment scenarios (IMI, IMI+DINO, and untreated control) across 12 study sites (n = 4 per treatment) over two breeding seasons (2025-2026). Preliminary results indicate that IMI and DINO detection rates are highest in ground foragers, and measured concentrations are greatest in sap feeders. This pattern suggests that foraging guilds have differing exposure scenarios. By quantifying neonicotinoid in forest birds, this study addresses a critical knowledge gap, thereby improving real world exposure scenarios in ecological risk assessments. These results will support evidence-based decision-making by land managers, pesticide regulators, and forest managers seeking to balance invasive species control with the conservation of forest biodiversity.

3.04.P-We309 Developing Robust Selenium Bioaccumulation Relationships

Bonner Anthony[1], Meredith Frenchmeyer[1], Sara Selden[1], Carolyn Meyer[1] and Anne Thatcher[1] (1)Arcadis

Selenium can be challenging when it comes to estimating movement through the food chain as it is strongly affected by factors such as biologically mediated speciation, sulfur content in soil, and plant species composition. Generic literature-based relationships are often used in risk assessment to estimate concentrations in vegetation and invertebrate tissue for use in food chain modeling. However, these values often do not represent actual field conditions and may over or underestimate uptake. This work presents the development of selenium bioaccumulation models for vegetation and terrestrial invertebrates for food web exposure modeling. Model development used paired datasets compiled from six former phosphate mine sites with similar climate, geology, habitats, and source material characteristics. Data included soil, above ground vegetation, and terrestrial invertebrate tissue. The dataset included 226 paired upland soil and vegetation samples, 92 paired riparian soil and vegetation samples, 119 paired soil and invertebrate, and 70 paired vegetation and invertebrate samples. Bioaccumulation relationships were evaluated using a range of models. Selection of the final model for each media pairing was based on predictive strength. Overall, the study demonstrates a practical framework for replacing generic literature values with regionally calibrated bioaccumulation models in ecological risk assessments. By integrating multiple comparable site datasets and explicitly evaluating statistical fit, data limitations, and ecological relevance, the approach improves the technical defensibility of dietary exposure estimates for birds and mammals. The resulting models provide a more realistic basis for estimating terrestrial invertebrate and vegetation selenium tissue concentrations at regional mine sites and may also inform risk assessments at other sites with similar upland or riparian conditions.

3.04.P-We310 Bayesian Benchmark Dose (BMD) Estimation Using Informed Priors From

Historical Control Data

Gunther du Hoffmann[1], Diana Temple[2] and Ryan Davis[3] (1)Eurofins EAG Agroscience Services LLC US, (2)Eurofins Scientific, (3)Eurofins EAG Agroscience Services

Prior work on the use of a virtual control group (VCG) in avian reproduction studies (SETAC 2025) showed how reliance on a single contemporaneous control group can affect the statistical power to detect an effect and, in turn, influence the final no observed effect concentration (NOEC). That work demonstrated that shifts in the statistical NOEC may reflect natural biological variability in the control group rather than a true, biologically meaningful effect of the test substance, with important implications for the reliability of risk assessment estimates. In contrast, the benchmark dose (BMD) with upper and lower confidence limits, estimated using a Bayesian model-averaging approach, provides a more informative measure of effect size and a clearer characterization of model uncertainty in the response pattern. Although earlier case studies presented by John Green et al. (2022) explored this concept, the present work improves confidence in prediction by applying the recommended statistical refinements and using random selection from the VCG to generate a more robust and realistic prior, including effect magnitude. This is necessary to account for the inherent variability reflected in the spread of the historical control data. Overall, this work helps distinguish true effects from spurious statistically significant findings or model-based estimates that do not adequately represent the observed response patterns.

Knowledge Gaps, Research Needs and Ecological Considerations to Improve Avian Exposure Assessments

3.04.V-01 Breed-Dependent CYP1A1 and Oxidative Stress Responses to Hydrocarbon Inhalation in an Avian Model

Vivian Oleforuh-Okoleh[1], Uchechukwu Obianwuna[2], Iyenemi Kakulu.[3], Onyinyechi Emeka[1] and Gabriel Adeoye[1] (1)Department of Animal Science, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt, (2)Institute of Feed Research, Chinese Academy of Agricultural Sciences, Beijing, China, Beijing, China., (3)Department of Estate Management, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt

Birds inhabiting petroleum-impacted environments may be exposed to airborne hydrocarbons, yet variation in xenobiotic metabolism and oxidative stress responses among avian populations remains poorly understood. Using chickens as an avian model, this study evaluated CYP1A1 regulation and oxidative stress responses following hydrocarbon inhalation. Chickens from four genetically distinct populations, including commercial and indigenous strains, were assigned to unexposed control and hydrocarbon-exposed groups. Birds in the exposed groups inhaled fumes generated from Bonny Light crude oil combustion under controlled conditions for four hours on alternate days over 35 days. Hepatic CYP1A1 expression was assessed as a marker of xenobiotic biotransformation, while malondialdehyde, superoxide dismutase, catalase, and glutathione peroxidase were measured as oxidative stress biomarkers. Hydrocarbon exposure induced CYP1A1 expression, increased lipid peroxidation, and altered antioxidant enzyme activities, indicating activation of xenobiotic metabolism and oxidative stress pathways. The magnitude of these responses differed among genotypes, with indigenous and commercial populations exhibiting distinct patterns of CYP1A1 activation and oxidative perturbation, suggesting variation in susceptibility and adaptive capacity under identical exposure conditions. These findings demonstrate that combining molecular and biochemical biomarkers can improve understanding

of avian responses to petroleum-derived contaminants and provide a mechanistic basis for avian exposure and effects assessment. This may improve the ecological relevance of exposure models and reduce uncertainty in predicting chemical effects across diverse bird populations.
Keywords: Hydrocarbon inhalation; CYP1A1; oxidative stress; avian exposure assessment; chicken genotypes; petroleum pollution

Disclaimer/Disclosure: This study was funded by the Tertiary Education Trust Fund (TETFund), Nigeria, under the National Research Fund (NRF) Grant No. TETFUND/DR&D/CE/NRF2020/SETI/04/VOL.1. The project was coordinated by Rivers State University, Port Harcourt, Nigeria.

Plants at the Crossroads: Their Role in Ecotoxicology, Risk Assessment and Environmental Protection

3.06.T-01 LED Light Quality, Quantity, and Nutrient Media Effects on the Growth of L. minor To Assess Possible Risk of Solvents Used in the Refining of Natural Gas Components to Aquatic Plants

Phoenix Nakagawa[1] and Ryan Prosser[1] (1)University of Guelph, School of Environmental Sciences

Natural gas sweetening is a process that increases gas quality and transportability by removing acidic co-extractants. The three major solvents used in the process are sulfolane, di-isopropanolamine (DIPA), and methyl-diethanolamine (MDEA), which are highly water soluble and non-volatile, making them ideal to enter and remain within the water column. Sulfolane, DIPA, and MDEA have been detected in ground and surface waters at current and historic natural gas processing sites in Alberta, Canada. The physicochemical properties of the compounds pose the greatest risk to aquatic plants due to this exposure pathway; toxicity assays are required to assess the risk to aquatic plants. Before assessing the possible effects of sulfolane, DIPA, and MDEA on the floating macrophyte Lemna minor, culture conditions for L. minor were optimized. We observed the growth and development of L. minor to develop a standardized frond-selection method to define 1) frond maturation, 2) the mature and immature fronds, and 3) frond selection. Then, we assessed the effect of LED light temperature (3000K and 5000K) and photosynthetic photon flux density (PPFD) on growth of L. minor. Finally, we assessed the growth media commonly utilized in Lemna sp. growth assays to assess optimal nutrient composition for growth. These optimized conditions were used to evaluate the toxicity of sulfolane, DIPA, and MDEA to L. minor.

3.06.T-02 Case Studies Using Halophytes To Remediate Saline Environments

Barbara Zeeb[1], Cassandra Collins[2] and Lyndsay Cartwright[3] (1)Royal Military College, (2)Queen's University, (3)Toronto Region Conservation Authority

Salinization of soils and water resources is an increasing environmental challenge in urban, industrial, and transportation corridors, driven by the widespread use of de-icing salts, industrial activities, and saline storm water runoff. Halophytes - salt-tolerant plants adapted to saline environments - offer significant potential for the remediation and management of these impacted systems. This presentation provides an overview of several ongoing collaborative projects examining the use of halophytes in diverse environmental remediation

applications. These include the rehabilitation of soils affected by road salt contamination, remediation of highly saline industrial soils, incorporation of halophytes into bioretention planters designed to intercept saline effluent, and the use of roadside halophytic plantings to reduce salt spray impacts on urban street trees and surrounding vegetation.

Across these systems, halophytes demonstrate multiple functional roles in remediation, including salt uptake and sequestration, stabilization of saline substrates, improvement of soil structure and hydrology, interception of saline runoff, and enhancement of ecological resilience in salt-impacted landscapes. The work highlights how these specialized plants can be integrated into green infrastructure and adaptive urban landscape management strategies to mitigate the environmental impacts of salinization.

3.06.T-03 Phytoremediation of Highly Saline Industrial Soils Using Native Halophytic Species at Former Oil and Gas Battery Site in Alberta, Canada

Cassandra Collins[1] and Barb Zeeb[2] (1)Queen's University, (2)Royal Military College

A multi-year field study is underway to evaluate the effectiveness of three native halophytic species in the remediation of highly saline soils at a former oil and gas battery site located approximately 100 km southeast of Edmonton, Alberta. Initial site characterization identified soil chloride concentrations exceeding 1,100 mg/kg in clay (43% clay, 35% silt) soils. The three native halophytic species being investigated are Chenopodium album (lambs quarters), Puccinellia distans (weeping alkiligrass) and Distichlis spicata (inland salt grass). Seeds were sown in designated plots during May of each field season, and plots continue to be monitored for plant growth and chloride accumulation. An unseeded control plot of equal size was also included. Soil samples were collected from the three planted and the control plot at depths of 0–15 cm and 15–30 cm. Plant tissue samples were collected, homogenized, and analyzed for chloride concentrations using ion chromatography at the end of the 2025 field season. Results demonstrated significantly lower soil chloride concentrations in plots where target halophytic species were established (467 mg/kg) compared to control plots (1041 mg/kg) at both sampling depths. Tissue analysis revealed that C. album exhibited the highest mean chloride accumulation (22,889 mg/kg), followed by P. distans (9880 mg/kg). D. spicata was not observed during the 2025 season, indicating poor establishment under the site conditions. Mean biomass production was also greatest in C. album (resulting in maximum salt removal of ~14.3 g/m2) highlighting the importance of species selection for maximizing biomass and chloride uptake in haloremediation applications. Findings from 2025 indicate that native halophytic species C. album and P. distans can tolerate and accumulate substantial chloride concentrations in highly saline industrial soils, supporting their potential use in phytoremediation of salt-impacted sites. Data collection is ongoing through the 2026 field season and two years of field data will be reported on.

3.06.T-04 Perchlorate Phytoremediation by Willow Cultivars (Salix spp.) in Military-Contaminated Soil

Benoît-Loup Denis-legault[1], Frederic Pitre[1], Julien Lamontagne[2] and Nicholas Brereton[3] (1)University of Montreal (UdeM), (2)Montreal University Health Centre (CHUM), (3)University College Dublin

Perchlorate (ClO_4^-) is a persistent and highly mobile contaminant associated with military activities, for which cost-effective soil remediation strategies remain limited. Although phytoremediation using willows (Salix spp.)

has shown promise in hydroponic systems, its effectiveness under realistic soil conditions remains underexplored. This study evaluated the phytoremediation potential of four willow cultivars (Sven (S. viminalis), SX64 (S. miyabeana), S. discolor and India (S. dasyclados)) in soil collected from the shooting berms of a training facility of the Canadian Army, co-contaminated with lead (Pb) and copper (Cu). A 12-week greenhouse experiment was conducted using a randomized complete block design (6 blocks, 90 pots) with three treatments: a water control, an ionic control (NaCl), and a perchlorate treatment (50 mg kg^{-1}). We hypothesized that willow cultivars would maintain normal growth and physiological parameters under perchlorate exposure, effectively reduce soil perchlorate concentrations compared to unplanted controls, and promote the enrichment of perchlorate-reducing bacteria in the rhizosphere. Growth and physiological parameters were monitored throughout, and perchlorate concentrations in soil and foliar tissues were quantified by liquid chromatography-mass spectrometry (LC-MS) at harvest. Soil bacterial communities were characterized by 16S rRNA amplicon sequencing.

Growth and physiological indicators remained unaffected by perchlorate exposure at 50 mg kg^{-1}, whereas co-contaminating trace elements (Pb, Cu) were the primary drivers of plant stress. Leaf perchlorate concentrations reached remarkably high values of 7 767-11 980 mg kg^{-1} dry weight, among the highest reported for willows to date. Soil perchlorate concentration was significantly lower in SX64-planted pots compared to unplanted controls. Perchlorate addition and willow cultivation had no significant effect on bacterial alpha or beta diversity, or on the abundance of perchlorate-reducing bacteria. These findings demonstrate the potential of willow cultivars, particularly SX64, as effective phytoextraction agents for perchlorate-contaminated soils, offering a promising plant-based solution for the remediation of military-impacted sites where conventional strategies remain limited.

3.06.T-05 TiO_2 Nanoparticles in Terrestrial Ecosystems: Multi-Factorial Phytotoxicity, Novel Quantification, and Food Chain Transfer

Abderrahmane Nabgui[1], Alejandra Moreno-Bayona[1], Théo Ségur[1], Olivia Renard[1], Laurie Kriegel[1], Frédéric Gimbert[2], Frédéric Candaudap[1] and Camille Larue[3] (1)CNRS, (2)Université Franche-Comté, (3)French National Centre for Scientific Research (CNRS)

TiO2 nanoparticles (NPs) are among the most produced engineered NPs worldwide thanks to their properties such as photocatalytic activity, chemical stability, and high refractive index. Yet, despite extensive research, their environmental fate and ecological impacts remain poorly understood, particularly within terrestrial ecosystems.

To address this gap, we designed a multi-factorial experiment to evaluate how (i) TiO_2 physicochemical properties (size, crystalline phase, coating; 8 particle types), (ii) plant traits (9 species: monocots vs. dicots), and (iii) soil organic matter content influence TiO_2 phytotoxicity. Our goal was to identify key drivers of NP phytotoxicity and transfer in terrestrial food chains. Preliminary results reveal species- and particle-specific phytotoxic effects, but no single dominant driver emerged, highlighting the complexity of NP-soil-plant interactions.

Ti quantification in edible tissues proved challenging due to Ti chemical inertness, which challenges acidic digestion efficiency. To overcome this, we developed a novel solid-sample quantification method using electrothermal vaporization coupled with ICP-AES (ETV-ICP-AES). By optimizing, calibration curve and the temperature program, we enabled accurate Ti quantification.

Finally, we selected one NP and one plant species (lettuce) to investigate Ti transfer in a soil-plant-snail food chain highlighting behavioral modifications (feeding and mobility) and genotoxicity in snails. Juvenile snails showed higher sensitivity than adult ones. Some of these effects were partially reversible after a 2-week "depuration step" feeding snails with uncontaminated lettuce.
Overall, our findings demonstrate the need to better account for environmental variability in environmental risk assessment to generate more robust and ecologically relevant conclusions.

3.06.T-06 Relevance and Development of a Standard Protocol for Overspray Tests With Aquatic Plants

Amelia Griffith[1], Ruth Albuquerque[2], Eric Bruns[3], Joanna Davies[4], Graeme Last[5], Kirsten McVean[6], Joern Roesner[7], Inge Van der Linden[8], Bastian Polst[9] and Magali Solé[10] (1)Eurofins Agroscience Services, (2)BASF SE, (3)Bayer AG CropScience Division, (4)Syngenta Ltd, (5)Corteva Agriscience UK Limited., (6)Noack Laboratorien, (7)DHD-Consulting GmbH, (8)FPS Health, Food Chain Safety and Environment, (9)Wageningen University and Research (WUR), (10)German Environment Agency (UBA)

The main method to control weeds in field crops is the use of herbicide sprays. Risk assessment guidance currently exists for non-target terrestrial plants (NTTP) from foliar exposure from spray drift (e.g., OECD 227 and OCSPP 850.4150) and studies are currently performed in laboratory settings. It is not known however if the results of the terrestrial risk assessment are sufficient to cover the risks to emergent or floating macrophytes exposed to spray drift.
Current regulatory studies expose floating aquatic plants such as Lemna spp. to herbicides and other chemicals via the water phase (e.g., OECD 221), which may not sufficiently cover the toxicity risk to aquatic plants from direct spray or spray drift. Standardized protocols for risk assessment of aquatic plants exposed via foliar spray drift do not currently exist. A SETAC working group was started in 2025 to discuss the need for such additional testing and develop a structured study design, combining key principles of existing guidelines for NTTP studies and OECD 221 studies. This presentation will outline methods and materials for a standardized protocol for an overspray test of Lemna spp., discuss the issues in the development of the protocol, and provide any existing results by participants of this working group. Once the relevance of this scenario has been proven and the testing methodology has been validated, this protocol shall be used to support future guideline developments.

Plants at the Crossroads: Their Role in Ecotoxicology, Risk Assessment and Environmental Protection

3.06.P-Tu103 Chemical Characterization of Sargassum Across the Caribbean and Southeastern United States: Implications for Coastal Management and Reuse

Summer Crescent[1], Emily Pisarski[2], Marie DeLorenzo[3], Nicholas Castillo[2] and Felipe Arzayus[3] (1)National Oceanic and Atmospheric Administration (NOAA), (2)National Centers for Coastal Ocean Science (NCCOS), (3)National Oceanic and Atmospheric Administration (NOAA)

Since 2011, large-scale influxes of Sargassum have increasingly impacted coastal ecosystems and economies throughout the Caribbean and southeastern United States. These inundation events can impact tourism and local livelihoods, but they also transport chemical contaminants to the shore, which can adversely affect human health and the coastal environment, highlighting the need for understanding chemical composition and its

implications for coastal management.
As part of an ongoing effort led by National Centers for Coastal Ocean Science, Sargassum samples have been collected and analyzed for trace metals and legacy organic contaminants across multiple regions, including Puerto Rico, the U.S. Virgin Islands, and Florida. Across all regions and years, Sargassum consistently contained a diverse suite of trace metals (e.g., Al, Fe, As, Mn, Zn, Cu) and detectable levels of legacy organic contaminants (e.g., PCBs, PAHs, pesticides), reflecting both natural biogeochemical processes and potential anthropogenic inputs. Major elements such as aluminum and iron were among the most abundant, while toxic metals such as mercury were typically present at low concentrations. However, certain elements of concern, including arsenic, were consistently elevated relative to other trace metals, with implications for biomass reuse and disposal strategies. Analysis for 180 persistent organic contaminants in Sargassum samples from 2021 revealed that the plants accumulated low levels of PCBs, DDTs, and PAHs, with PCBs being the most prevalent compound class. PBDEs were not detected.
Spatial comparisons suggest that coastal processes, including terrestrial runoff and sediment interaction can influence chemical contaminant composition. Additionally, the presence of both trace metals and organic pollutants within Sargassum highlights its potential role as an integrator and transport vector of coastal contaminants.
This work represents one of the first multi-year, multi-region chemical characterizations of pelagic Sargassum across the Caribbean and southeastern U.S. and provides critical data to inform risk assessments, biomass management strategies, and coastal response efforts. These findings support ongoing NOAA initiatives to integrate chemical monitoring into Sargassum response frameworks and improve decision-making for coastal communities impacted by recurring inundation events.

3.06.P-Tu105 Adaptive Partitioning of per- and Polyfluoroalkyl Substances in Forage Grasses After Long-Term Exposure

Landon Keele[1], Jason R. Masoner[2], Dana Kolpin[3] and Erin Pulster[4] (1)U.S. Geological Survey Columbia Environmental Research Center; University of Missouri, (2)U.S. Geological Survey Oklahoma-Texas Water Science Center, (3)U.S. Geological Survey Central Midwest Water Science Center, (4)U.S. Geological Survey Columbia Environmental Research Center

Per- and polyfluoroalkyl substances (PFAS) are xenobiotic fluorinated compounds resistant to natural processes of degradation, enabling widespread and persistent environmental contamination. Within agricultural systems, a frequent source of PFAS exposure is through the application of biosolids, with millions of acres of U.S. farmland annually amended with potentially contaminated biosolids produced by waste treatment facilities. The entirety of the ecotoxicological effects of this exposure are yet unknown, but forage crops grown on these contaminated soils have been confirmed to both uptake and bioaccumulate a wide range of PFAS, endangering human food systems through trophic accumulation and magnification. This study evaluates the propensity of ryegrass (Lolium multiflorum) and Bermuda grass (Cynodon dactylon) to accumulate 52 tested PFAS on agricultural fields amended with contaminated biosolids over variable timelines, as well as the preferential partitioning of these PFAS within roots or aboveground vegetation compartments. Further, we present a novel evaluation of transfer factors from bulk soil → rhizosphere → root tissues → vegetation for two grasses. Our results indicate that the evaluated forage crops have temporally variable responses and partitioning patterns with long-term exposure to PFAS, demonstrating that these plants have an increased capacity to store PFAS in their aboveground vegetative compartments after long-term exposure when compared to plant populations only

recently exposed to PFAS through applications of contaminated biosolids. This increase in vegetative bioaccumulation of PFAS after long-term exposure may potentially improve soil health on contaminated agricultural lands, as well as improve our understanding of phytotoxic stress response in the presence of PFAS.

3.06.P-Tu106 Vetiver Grass as a Nature-Based Remediation Strategy for Gully Erosion Control and Landscape Restoration in Tropical Ecosystems

Adaku Ahuzi[1], Emmanuel Okafor[1], Nneka Emmanuel[1], Onwuchekwa Ojimgba[1] and Mary Iwuagwu[1] (1)Abia State University, Uturu

Gully erosion is one of the most severe forms of land degradation in tropical landscapes, driven by intense rainfall, deforestation, unsustainable land-use practices, and fragile soils. Nature-based solutions, particularly vegetative interventions, have gained prominence as sustainable approaches to gully erosion control. This study assessed the effectiveness of vetiver grass (Vetiveria zizanioides L. Nash) in enhancing soil moisture retention and stabilizing gully slopes in Umuturu-Ezemazu Urualla, Imo State, Nigeria. The gully site was sand-filled and divided into five slopes. Fifteen-week-old vetiver tillers, pre-treated with 25 ppm indole-3-acetic acid (IAA) to enhance rooting, were established on the slopes. Some slopes were left unvegetated to serve as controls. Soil moisture content was measured at seven depths (10-70 cm) one year after establishment and within 24 hours following a major storm event to assess soil water retention under near-saturated conditions. Vetiver-planted slopes exhibited consistently higher soil moisture across all depths, with increases of 101.8-161.5% relative to controls. Peak moisture retention occurred at the 20-30 cm soil layer, corresponding to the zone of highest root density. The substantial enhancement of subsurface moisture in vetiver plots indicates improved soil structure and slope stability. These findings demonstrate that vetiver grass is an effective, low-cost nature-based solution for gully erosion control and the rehabilitation of degraded tropical landscapes. By enhancing soil moisture retention and stabilizing gully slopes, vetiver establishment can contribute to erosion control, landscape restoration, and the long-term sustainability of ecosystems at risk of degradation.

3.06.P-Tu107 Development of a Method To Test Non-Target Terrestrial Crop Species in an Aquatic Submergence Exposure Scenario

Ashlee Kirkwood[1], Daniel Edwards, PhD[2] and Lily Nolan[1] (1)Smithers, (2)BASF Agricultural Solutions US LLC

An evolving regulatory landscape within the United States Environmental Protection Agency (US EPA) coupled with the Endangered Species Act (ESA) are changing approaches for pesticide assessment, registration, and labeling. For exposure risk to terrestrial plants, effects endpoints are typically derived from guideline studies using overhead spray exposure, such as the vegetative vigor (OCSPP 850.4150) or seedling emergence (OCSPP 850.4100) tests. Exposure of off field, non target plants to dilute herbicide runoff from precipitation events, however, differs greatly from direct spray application, potentially influencing plant uptake and toxicity. With the downstream goal of running tests that could compare plants exposed in an aquatic submergence scenario versus a traditional (e.g., foliar) spray application, it was necessary to determine whether the standard terrestrial crop species used for US EPA guideline studies could tolerate and survive periods of submergence in water. Six dicotyledon species (cabbage, cucumber, radish, soybean, sunflower, and tomato) and four monocotyledon species (corn, onion, perennial ryegrass, and rice) were submerged for either 0-, 1-, 6-, or 24-hours in dechlorinated tap water. Following this submergence period, plants were maintained in a greenhouse facility and were then evaluated at 21-days from 0-hour, the duration of a vegetative vigor exposure conducted

according to OCSPP 850.4150. Plants were evaluated for health (survival and sub-lethal phytotoxicity) and growth (shoot length and shoot dry weight). Three species (onion, perennial ryegrass, and soybean) were generally unaffected by submergence in water, up to a duration of 24-hours. Four species (cabbage, cucumber, rice, and sunflower) were affected in all submergence groups in at least one parameter (phytotoxicity, shoot length, or shoot dry weight). The remaining species (corn, radish, and tomato) were able to tolerate up to 1- or 6-hours of submergence in water with little to no impact to health or growth.
Overall, this work is an important first step towards developing methods to capture toxicity to non-target terrestrial plants under exposure scenarios not currently captured in guideline studies.

3.06.P-Tu108 Towards Explainable Prediction of Engineered Nanomaterials Uptake, Behavior and Ecotoxicity Using Machine Learning and Molecular Dynamics-Computed Nanodescriptors

Abderrahmane Nabgui[1], Merve Tunali[2], Bernd Nowack[2], Astrid Avellan[1] and Camille Larue[1] (1)French National Centre for Scientific Research (CNRS), (2)Swiss Federal Laboratories for Materials Science and Technology (EMPA)

Engineered nanomaterials (ENMs) have received considerable attention over the last decades due to their wide range of applications in agriculture, medicine, cosmetics, etc., as well as their potential environmental effects and ecotoxicity. Studying the interactions between ENMs and living organisms to understand their fate and potential impacts is therefore essential. However, the large number of variables involved in these interactions makes them challenging to study experimentally and the results difficult to interpret. Consequently, predicting the properties, fate, effects, and efficacy of ENMs remains a challenge. Interpretable machine learning (ML) is a promising approach that allows us to leverage the rich data available in the scientific literature to develop meaningful models explaining the fate and effects of ENMs on living organisms and the environment. This presentation will explore how ML can help predict the properties, fate, and effects of ENMs.
In this work, we developed a ML classifier that predicts the ecotoxicity of nanomaterials in terrestrial ecosystems with an accuracy of 67%. Interpretable post-hoc algorithms showed that nanomaterial type, exposure stage, species classification, ENMs surface charge, and soil pH are the main driving factors of ENM toxicity. However, the lack of ENMs characterization in the available data hinders a mechanistic interpretation of these results. For instance, hydrophobicity, a parameter suspected to play an important role in ENMs uptake and behavior in biological systems, is very difficult to measure experimentally. A possible alternative is to develop new characterization approaches based on molecular dynamics (MD) simulations to compute relevant nanodescriptors, thereby enabling their incorporation into ML models and meta-analyses. The second part of this talk will present the creation of a virtual representation of ENMs and the computation of multiple nanodescriptors, including the water radial distribution function, solvent-accessible surface area, solvation shell properties, hydrogen bonding, and the water tetrahedral parameter, using MD simulations. These descriptors enabled the development of a hydrophobicity model, achieving an R^2 of 79%. Finally, as a future perspective, we aim to incorporate these nanodescriptors into the interpretable ML model to shed light on the role of hydrophobicity in the fate, behavior, and effects of ENMs in living organisms and the environment.

3.06.P-Tu110 Copper Nanoparticle Properties Driving Their Transformation and Fate at Plant Leaf Interfaces

Aude CALAS[1], Fadoua SALLEM[1], Hiram CASTILLO-MICHEL[2], Abderrahmane NABGUI[1], Gabriel SGABIERO[2], Mickaël WAGNER[1] and Astrid AVELLAN[1] (1)CNRS - GET, (2)ESRF

Copper is an essential micronutrient for plant growth, but its extensive agricultural use has led to significant soil accumulation, particularly in Europe. Copper-based nanoparticles (Cu-based NPs) have emerged as a potential alternative to conventional Cu applications. However, using Cu-based NPs raises questions about their accumulation, transformation, and behavior in soil-plant systems. The first critical step is their interaction with leaf surfaces. While foliar uptake of NPs is now established, key questions remain: How do the initial speciation, shape, and dosage influence absorption and cellular distribution? Do NPs persist after foliar uptake? How is their speciation modulated? To address these questions, tomato plants were grown in a Cu-depleted sand medium in a controlled growth chamber. Leaves were exposed via drop deposition to three Cu-based NPs of similar size (spherical CuO, rod-shaped CuO, spherical CuS) at dosages of 3, 20, or 40 µg per plant. Total Cu was analyzed in 4 compartments: rinsing solution from exposed leaves containing NP remaining at the leaf surface, washed leaves (to assess the taken up Cu), aerial parts, and roots. Micro-X-ray spectroscopy determined Cu distribution and speciation in exposed leaves. Results showed NP-dependent foliar uptake: at similar dosages, CuS uptake was 20× higher than CuO NPs, with rod-CuO more absorbed than spherical CuO. These differences likely stem from shape (rod vs. sphere), zeta potential (CuS: −; CuO: +), hydrophobicity, and/or dissolution rates. Post-uptake, CuS and CuO NPs exhibited distinct cellular behaviors, likely due to differing uptake rates. Cu was associated with cuticular pegs of the leaf epithelium, strongly suggesting cuticular absorption as a major foliar uptake route. For CuO NPs, Cu linked to carboxyl groups in the cuticular pegs suggests immobilization in the epithelium. At 40 µg CuS, Cu associated with histidine in the spongy mesophyll, indicating cellular intake, active plant regulation, and potential immobilization/transport. While Cu translocation to remote tissues was not observed, NP persistence in exposed leaves after 40 days seems likely, pending further validation. This work highlights the high potential of CuS NPs as Cu foliar delivery carriers, given their remarkably high uptake. However, the NPs persistence in plant tissues remains to be investigated, particularly as Cu-based NPs are known to be toxic to microorganisms, invertebrates, plants, and human cells.

3.06.P-Tu111 Sequential Integration of Invasive and Native Plants for Phytoextraction of Heavy Metals and Critical Minerals

Delaney Bellis[1] and Sarah Donaher[1] (1)University of Tennessee Knoxville

Phytoextraction is a cost-effective, nature-based strategy for capturing contaminants in polluted soils, but is currently limited by time requirements, plants' susceptibility to high pollutant concentrations, and high biomass requirements for substantial contaminant recovery. Here, we investigate a framework that relies on sequential integration of invasive plant species as bioindicators of soil contamination and known hyperaccumulator native plants for phytoextraction of heavy metals (HMs) and critical minerals (CMs), ultimately providing a dual benefit of materials recovery and ecological restoration in contaminated ecosystems. Invasive plants are prevalent in disturbed ecosystems and produce substantial biomass, creating an opportunity to leverage these species for materials extraction and biomonitoring. Since invasion status alone does not indicate likelihood of significant HM and CM accumulation, and there is an overall lack of data for some of the most widespread invasive species, including English ivy (Hedera helix) and kudzu (Pueraria montana), species- and contaminant-

specific data is necessary to inform remediation efforts. We hypothesize that H. helix and P. montana will exhibit differential HM and CM tolerance and accumulation patterns compared to native species, as well as limited phytotoxicity during HM and CM exposure. Invasive plant sampling across east TN and subsequent analysis for HMs and CMs via ICP-MS will provide baseline HM and CM tissue concentrations, ultimately informing concentration selection for controlled accumulation experiments and functional categorization of these species. Preliminary results indicate copper and zinc concentrations in H. helix tissue are consistent with other field-collected species analyzed for baseline metals, including grasses, shrubs, and herbaceous weeds.

3.06.P-Tu112 Use of Flow Cytometry for the Determination of Cell Density in Algal Toxicity Tests

Joshua Arnie[1] and Raven Robinson[1] (1)Eurofins Agroscience Services

Algal toxicity tests are conducted according to OECD201 and OCSPP 850.4500 test guidelines. The objective of these bioassays is to evaluate the potential impact of a test substance on the growth of an isolated algal species. All endpoints are derived from changes in cell density, determined from samples collected throughout the exposure period. Cell density is commonly determined using electronic particle counters, fluorescence quantification, or manual counts using a hemacytometer and microscope.
Flow cytometry is commonly used for quantifying multiple cell types in given sample, however, there has been little to no documented use of this technology for algal toxicity tests conducted according to Good Laboratory Practices. The use of this instrument would be beneficial in improving efficiency in the lab, reducing the occurrence of human error when preparing or enumerating samples, and allowing for automated counts. This poster will outline methodologies for use of the CytoFLEX platform, present data obtained using conventional counting methods and the CytoFLEX, and discuss potential benefits and challenges with the adaptation of this technology for application.

3.06.P-Tu113 Estimating 50% Effect Rates From Plant Visual Injury: A Decision Tree for Non-Target Terrestrial Plant Risk Assessment

Gunther du Hoffmann[1] and Joshua Arnie[2] (1)Eurofins EAG Agroscience Services LLC US, (2)Eurofins Agroscience Services US

Plant visual injury (PVI) is increasingly considered relevant in non-target terrestrial plant (NTTP) risk assessment, but guidance on scoring, statistical analysis, and data reliability remains limited. Building on earlier work by the SETAC Plant Visual Injury Working Group, we developed a practical decision tree to support more consistent estimation of 50% effect rates from PVI data. We reviewed commonly used scoring approaches and combined new approach methodologies (NAMs) with established statistical best practices to guide endpoint selection. The framework helps align analytical methods with different scoring systems and provides an interim path toward more harmonized, transparent, and regulatory-relevant use of PVI data.

3.06.P-Tu115 Dual Effect of Silver Nanoparticles on Allium cepa Root Growth and Pseudomonas Inhibition

Carlos Juárez-Salinas[1], Carlos Fernández-Rendón[2], Enrique Barrera-Calva[2], Patricia Ramírez-Romero[2] and Reyna Ventura-Reyes[1] (1)Universidad Abierta y a Distancia de México, (2)Universidad Autónoma

Metropolitana-Iztapalapa

Silver nanoparticles (AgNPs) are among the most widely used nanomaterials worldwide across sectors such as the pharmaceutical, food, biomedical, textile, and agricultural industries, due to their high antimicrobial activity. The physicochemical properties of AgNPs, such as size, shape, and stability, can cause different toxic effects and accumulation in different organisms such as mammals, plants, and bacteria. In the agricultural context, AgNPs have attracted significant interest due to their potential to improve crop growth and their properties to combat phytopathogenic microorganisms. This study aimed to evaluate the effects of silver nanoparticles (AgNPs) on Allium cepa growth and their capacity to inhibit Pseudomonas species. The AgNPs were synthesized via a chemical reaction using sodium borohydride and sodium citrate, and characterized by X-ray diffraction, transmission electron microscopy (TEM), and UV-Vis spectroscopy. Bioassays were performed using onion roots exposed to varying AgNP concentrations, alongside bacteria of the Pseudomonas genus. The AgNPs at 5 mg/L promoted onion root growth, whereas concentrations above 50 mg/L inhibited root elongation. The 10% inhibitory concentration (IC_{10}) for root growth was 9 mg/L, and the median inhibitory concentration (IC_{50}) was 46.01 mg/L. For bacteria, the minimum inhibitory concentration (MIC) ranged from 5 to 10 mg/L for P. fluorescens, P. aeruginosa, and P. putida. These findings suggest that AgNPs can inhibit beneficial Pseudomonas species for plants but may also be used to control phytopathogenic bacteria with minimal inhibition on Allium cepa.

Plants at the Crossroads: Their Role in Ecotoxicology, Risk Assessment and Environmental Protection

3.06.V-01 Bioaccumulation of PFAS in South Florida Mangrove Ecosystems

Preetika Chand[1], Natalia Soares Quinete[1] and Oscar J. Valverde-Barrantes[1] (1)Florida International University

Mangrove forests are important coastal ecosystems that act as natural filters for pollutants and contaminants. Their complex root systems trap sediments and associated contaminants, yet little is known about how mangroves interact with per- and polyfluoroalkyl substances (PFAS), a class of persistent synthetic contaminants widely detected in coastal environments. This study evaluates PFAS accumulation in mangrove ecosystems across contrasting environments in South Florida, including sites in the urbanized shorelines of Biscayne Bay and the protected wetlands of Everglades National Park (Shark River and Taylor Slough). Two dominant mangrove species, Rhizophora mangle (red mangrove) and Laguncularia racemosa (white mangrove), were collected in order to determine whether species' root traits influence PFAS uptake and retention. We hypothesize that PFAS concentrations will be greater in Biscayne Bay due to higher anthropogenic influence, and that species with greater root permeability and lower hydrophobic barrier development will exhibit higher PFAS bioaccumulation. Paired sediment and root samples were analyzed for 40 PFAS compounds using liquid chromatography-tandem mass spectrometry. Fine root cross sections were also examined to quantify hydrophobic root barriers such as suberization and Casparian band development. Bioaccumulation factors were calculated as the ratio of PFAS concentrations in roots relative to surrounding sediments to compare uptake efficiency among species and sites. Preliminary findings suggest detectable PFAS in both sediments and mangrove roots, with higher concentrations in sediments. Differences in accumulation between species are also expected due to contrasting salt regulation strategies and root barrier development. This research improves

understanding of plant-contaminant interactions and helps improve coastal monitoring efforts and inform management strategies for contaminated coastal wetlands.

Wildlife Ecotoxicology: Exposure, Accumulation and Effects

3.07.T.A-01 Spatial and Temporal Assessment of Reproductive and Immunotoxic Effects in Colonial Waterbirds at Contaminated Great Lakes Sites in Michigan (2010-26)

Keith Grasman[1], Riley Cornwell[2], Abigail Vanden Heuvel[2], Drew VanWoerkom[2], Mandy Annis[3], Amanda Curtis[3] and Lisa Williams[3] (1)Calvin University and Wings Over Water Research Institute, (2)Calvin University, (3)U.S. Fish and Wildlife Service

Colonial waterbirds are excellent sentinels for assessing and monitoring populations, reproduction, and health effects (e.g., immunotoxicity) of persistent organic pollutants. This long-term Great Lakes program has monitored fish-eating birds in the Saginaw River and Bay and River Raisin Areas of Concern (AOCs) and in Grand Traverse Bay from 2010-26. Although not an AOC, Grand Traverse Bay was studied because of its high levels and unique mixture of contaminants. Herring gull eggs in both AOCs had high dioxin equivalents (TEQs) driven by planar polychlorinated biphenyls. Eggs from Bellow Island in Grand Traverse Bay had elevated TEQs from polychlorinated dibenzo-p-dioxins and dibenzofurans. Reference sites were in the lower St. Marys River (herring gulls and Caspian terns), eastern Lake Superior (terns), and eastern Lake Huron (black-crowned night herons). Previously published assessments of the first decade of monitoring (2010-19) showed ongoing biological effects relevant to management issues including legacy contaminants and chemicals of emerging concern in AOCs, other contaminated areas, and lake-wide regions. The objective of this talk is to integrate later years (2021-24, 26) into this assessment with emphasis on time trends. Relative risk ratios for embryonic nonviability (infertility and mortality) in gull embryos generally were 2-3 fold higher than reference in both AOCs and Grand Traverse Bay. Deformities (e.g., crossed bills, gastroschisis, edema) were found in embryos and chicks at contaminated sites. Productivity of 4-week-old tern chicks in Saginaw Bay was 40% lower than reference. In the River Raisin AOC, productivity of 4-week gull chicks was poor in 9 of 14 years. Breeding Caspian terns, a state-threatened species, declined 42% in the Saginaw River and Bay AOC (2007 to 2023). Nesting herring gulls in the main breeding area decreased >95% in the River Raisin AOC (2015 to 2023), with complete reproductive failure or absence during the last five years. The phytohemagglutinin skin response (T cell-mediated immunity) was suppressed 51-56% in gull chicks at all contaminated sites, and 48- 50% in terns and 33% in herons in Saginaw Bay. Antibody titers in gull chicks in the River Raisin AOC and Grand Traverse Bay were 1.3-1.6 fold lower than reference. Time trend analyses showed no significant improvements in key reproductive and immunological endpoints in the AOCs or Grand Traverse Bay, including during the most recent five years of monitoring.

3.07.T.A-02 Decades of PFOS Monitoring in Canadian Wildlife: Temporal Trends, Spatial Patterns, and Species Differences

Shane de Solla[1], Kimberley Hughes[2], John Elliott[3], Mary Gamberg[4], Raphael Lavoie[5], Jennifer Provencher[5], Julianna Colafranceschi[1] and Emily Choy[1] (1)McMaster University, (2)Broadwing Biological Consulting, (3)Environment and Climate Change Canada (retired), (4)Gamberg Consulting, (5)Environment and Climate Change Canada

Perfluorooctane sulfonate (PFOS), despite widespread restrictions on production and use, remains the dominant perfluoroalkyl substance (PFAS) detected in animal tissues. Using national-scale datasets from the Chemicals Management Plan (CMP) and other federal monitoring programs, we report temporal and spatial trends in PFOS concentrations in bird eggs across Canada and in caribou liver from the Canadian Arctic. Long-term seabird data show PFOS generally increased from the 1970s, peaked between the late 1990s and 2010, and declined thereafter. For example, PFOS in northern gannet eggs declined significantly after peaking in the late 1990s, consistent with global production phase-outs. Between 2008/09–2023, PFOS declined at 59% of gull and 41% of starling colonies/sites monitored under the CMP. Concentrations were highest in the Great Lakes—particularly near urbanized or industrial centres—and lowest in the Arctic, varying by up to three orders of magnitude across sites. Marine and Arctic seabirds generally had lower levels, likely reflecting long-range transport, while freshwater species were more influenced by local sources. Great Lakes Herring gulls exhibited higher concentrations at lower Great Lakes colonies and greater spatial variation than co-located cormorants, reflecting dietary and ecological differences. In two Arctic caribou herds, PFOS in liver declined significantly in one herd after 2005, while the other showed higher but stable levels. In starlings, PFOS concentrations were highest at landfills>industrial sites> rural sites. These findings highlight both the effectiveness of regulatory actions and the persistence of regional hotspots linked to ongoing losses from consumer products and point sources

3.07.T.A-03 Growth Impairment and Reduced Post Natal Dispersal in Neonicotinoid Exposed Tree Swallow Nestlings With Lack of Supplemental Omega 3 Protection

Christy Morrissey[1], Biyao Han[1], Sonia Cabezas[1] and Margaret Eng[2] (1)University of Saskatchewan, (2)Environment and Climate Change Canada

Increased application of neonicotinoids has altered the acute insecticide toxic loading of North American agricultural landscapes leading to decreased insect abundance which are important food for insectivorous birds. Concurrent shifts in the landscape from wetlands and other natural areas to cropland further leads to habitat loss and decreased food quality, as aquatic insects are the major sources of nutritious omega-3 polyunsaturated fatty acids (PUFAs) such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). For aerial insectivores, such as tree swallows, supplementary omega-3 has previously been shown to enhance the growth and development of nestlings in captivity, but this has not been proven in the field. We hypothesized that supplemental omega-3s can promote growth of tree swallow nestlings and also mitigate the toxicity from oral neonicotinoid exposure. In 2022 and 2023, we examined the toxicity of two neonicotinoids, imidacloprid and clothianidin, on the development of free living tree swallow nestlings in several agricultural sites by orally dosing them in their nestboxes with high omega-3 enriched fish oil or low omega-3 sunflower oil from day 6 to day 10 of age. On day 7, we added a single dose of imidacloprid at 0, 4, 6, 9 or 13 µg/g b.w. or clothianidin at 0, 11, 23, 46, or 95 µg/g b.w. and monitored their daily growth, and post-fledging survival and dispersal

movements with nanotags and the Motus wildlife telemetry system. Our results showed both neonicotinoids exerted significant dose-dependent effects impairing the growth and mass of nestlings. Nestlings exposed to the highest dose of imidacloprid (13 µg/g b.w.) also had a lower probability of successfully leaving their natal sites and a shorter dispersal distance. However, the supplementary omega-3 administration did not elevate the blood PUFA levels and nestlings did not show any significant effects on the growth and toxicity. This research has implications for understanding the benefits of conserving aquatic habitats for avian wildlife exposed to agricultural stressors including pesticides.

3.07.T.A-04 Molecular Effects of PFAS in Four Seabird Species in the St. Lawrence: A Transcriptomic Approach

Laurianne Richard[1], Raphaël Lavoie[2], Shane de Solla[2] and Valérie Langlois[1] (1)National Institute for Scientific Research (INRS), (2)Environment and Climate Change Canada (ECCC)

Seabirds have long been recognized as sentinel species for monitoring environmental contamination. Previous studies in seabirds have shown that persistent organic pollutants, such as per- and polyfluoroalkyl substances (PFAS), can disrupt multiple physiological pathways. This study aims to investigate and compare the toxicological responses associated with PFAS contamination in four seabird species—the northern gannet, the Atlantic puffin, the razorbill, and the common murre—using transcriptomics. Blood samples were analyzed to measure 17 compounds from the PFAS family, including 13 perfluorocarboxylic acids (PFCA) and four perfluorosulfonic acids (PFSA). Overall, the northern gannet had the highest total PFAS concentrations among the species studied, followed by the Atlantic puffin, while the common murre and the razorbill had comparable levels. PFSA were predominantly associated with the northern gannet, while PFCA were more prevalent in the three species of alcids. To characterize the molecular responses associated with PFAS exposure, RNA-seq was used to assess gene expression. In the northern gannet, the analysis showed that 218 genes were significantly altered and were involved in physiological pathways related to energy and mitochondrial metabolism, immunity and inflammation, and the cell cycle. Results for alcids will also be presented. This study combines advanced molecular analyses to link environmental contamination to the effects detected in seabirds.

3.07.T.A-05 Could Parasites Serve As Sentinels of Microplastic Contamination in South Atlantic Penguins?

Bruna Carmo de Oliveira[1], Ana Cristina Caires Queiroga[1], Max Rondon Werneck[2], Daniela Mariani[2], Paula Baldassin[2] and Felipe Micali Nuvoloni[1] (1)Universidade Federal do Sul da Bahia, (2)Instituto BW

Marine plastic pollution has become a major global environmental concern, particularly in marine food webs where microplastics (MPs) may undergo trophic transfer and bioaccumulation. However, the occurrence of microplastics in marine parasites remains largely unexplored. This study aimed to characterize and quantify microplastics detected in Contracaecum parasites collected from the stomachs of juvenile Magellanic penguins (Spheniscus magellanicus) found along the north coast of Rio de Janeiro State, Brazil. The study evaluated their potential as bioindicators of microplastic contamination and trophic transfer pathways. Parasites were chemically digested using 5–10 mL of previously filtered 10% potassium hydroxide (KOH) and incubated at 45 °C for 24 h. The solution was filtered and analyzed under a stereomicroscope for particle counting and morphological characterization. Microplastics were detected in 83.3% of parasite samples (10/12), with an average abundance of 5.58 ± 4.44 particles per individual. In the procedural controls the contamination was

substantially lower (57.1%; 4/7), with a mean abundance of 1.86 ± 2.04 particles. Fisher's exact test demonstrated higher contamination in parasites compared to controls (odds ratio = 27.8; p = 0.006), supporting the biological origin of most recovered particles. A total of 67 microplastic particles were isolated from Contracaecum, with a predominance of fibers (53.7%; n = 36), followed by fragments (35.8%; n = 24) and spheres (10.4%; n = 7). Black particles were the most frequent color category. Fiber lengths ranged from 0.01 to 2.99 mm, whereas fragments ranged from 0.011 to 0.35 mm and spheres from 0.02 to 0.03 mm. Generalized linear models revealed higher MP abundance in penguin parasites compared to controls, while parasite weight showed no relationship with particle abundance. Because all hosts analyzed were juveniles (<1 year old), contamination may have occurred through parental regurgitation or ingestion of contaminated prey during early foraging stages. These findings provide preliminary evidence of trophic transfer of MPs within South Atlantic marine food webs and represent the first report of microplastics detected in parasites. Overall, the study highlights the potential application of Contracaecum parasites as innovative biomonitors of microplastic contamination in marine ecosystems and opens new perspectives for investigating microplastic transfer through marine host–parasite systems.

3.07.T.A-06 Non-Monotonic Effects of Environmentally Relevant Pollutant Mixtures on Common Frog (Rana temporaria) Tadpoles

Lavanya Vythalingam[1], Amelia Munson[2], Claus Svendsen[3], Cedric Laize[4], Dominique Anderson[5], Tomas Brodin[6] and Frances Orton[5] (1)Heriot-Watt University, (2)Swedish University of Agricultural Sciences (SLU), (3)UK Centre for Ecology and Hydrology, Wallingford, Oxfordshire, (4)UK Centre for Ecology and Hydrology, Wallingford, (5)Heriot Watt University, (6)Swedish University of Agricultural Sciences (SLU)

The common frog (Rana temporaria) is widely distributed across Europe and inhabits freshwater environments such as ponds and wetlands, which may be vulnerable to chemical contamination. Increasing evidence suggests that contaminant mixtures, rather than single chemicals, often drive adverse effects in wildlife. Importantly, these mixtures reflect ecologically realistic exposure scenarios, as wildlife are typically exposed to complex contaminant mixtures rather than single chemicals in natural environments. Here, we conducted a field study to formulate environmentally relevant contaminant mixtures based on >100 organic and metal analytes collected from 18 UK ponds. Three mixtures (Mix A/B/C) representing different pollutant combinations and a static concentration of metals [145 ug/L] were identified using a multivariate approach. We examined the effects of these mixtures [5 concentrations each, between 0.0079–6549 ng/L], as well as a standalone concentration of metals (145 µg/L), and Mix C ('median' environmental level: 65.49 ng/L, no metals) on survival, development, growth, liver detoxification (metallothionein, CYP3A, GST gene expression), and neurotoxicity in tadpoles. Survival was negatively impacted by all the mixtures at the highest and lowest concentrations with the strongest effects observed at the lowest concentrations (A: 31-fold; B: 19-fold; C: 20-fold). Tadpole development timing did not differ significantly among treatments. Morphological traits were strongly stage-dependent ($p < 0.001$), with treatment-specific effects on snout–vent length and head width, while body mass and tail width showed no significant response. No treatment effects were observed for GST and CYP3A expressions. However, Metallothionein expression was significantly affected by treatment ($p = 0.02$), and across development (interaction $p < 0.05$) with reduced expression in single metals and median Mixture C treatments relative to the control. Overall, these findings demonstrate that environmentally relevant pollutant mixtures can induce complex, non-monotonic

biological responses, with low-level exposures driving unexpectedly high mortality and complex effects on growth. These results highlight the need to incorporate mixture effects and realistic exposure scenarios into ecological risk assessments.

Wildlife Ecotoxicology: Exposure, Accumulation and Effects

3.07.T.B-01 Contaminant Exposure Tracks Regional Land Use Across the Annual Range of the Endangered Whooping Crane (Grus americana)

Susari Malala Irugal Bandaralage[1], Mark Bidwell[2], Maureen Angell[3], Diana Christie[4], Nicolas Comerford[5], John Conkin[2], Carter Crouch[6], Katrina Fernald[6], Abraham Kanz[7], Rebecca Magnus[1], Lukas Mundy[3] and Bruce Pauli[3] (1)Nature Saskatchewan, (2)Canadian Wildlife Service, Environment & Climate Change Canada, (3)Environmental Effects Research Division, Environment & Climate Change Canada, (4)Wilder Institute, (5)Wood Buffalo National Park, Parks Canada, (6)International Crane Foundation, (7)Crane Trust

Endangered whooping cranes (Grus americana; WHCR) of the Aransas Wood Buffalo population face environmental stressors across their 3,800 km migratory range. These landscapes overlap with intensive agriculture and industrial development, raising concerns regarding WHCR exposure to complex mixtures of legacy and emerging contaminants and their implications for wildlife and ecosystem health more generally. Our objectives were to (1) quantify contaminant concentrations in wetlands used by WHCR and (2) compare contaminant profiles across regions to identify elevated exposure risk. Abiotic samples were collected from 92 wetlands across five regions: 28 remote breeding sites in northern Canada; 45 migratory stopover sites: 18 in the Alberta Oil Sands Region (AOSR), 13 in Saskatchewan (SK), 14 in Nebraska (NE); and 19 wintering sites on the Texas Gulf Coast (TX). At each site, water and sediment samples were collected and, at most sites, passive samplers were deployed for between 27 and 41 days. Water samples were analyzed for 24 trace metals; sediment samples for 161 polychlorinated biphenyl congeners and 106 pesticides; and passive samplers for 60 naphthenic acids and 76 polycyclic aromatic compounds. Preliminary results reflect regional land use patterns. Wetlands in agricultural regions (SK and NE) exhibited elevated concentrations of agrochemicals and select trace metals, whereas wetlands associated with greater industrial activity (TX and AOSR) contained higher concentrations of contaminants linked to oil and gas development. These findings suggest that WHCR may experience repeated exposure to contaminants throughout migration and wintering periods, potentially contributing to cumulative toxicological burden across the annual range. Given the strong site fidelity exhibited by cranes, repeated use of contaminated wetlands may increase chronic exposure and bioaccumulation. Although direct effects on WHCR health remain unresolved, our results identify exposure pathways warranting further investigation. Future analyses will integrate environmental data with biological sampling to evaluate bioaccumulation and potential sublethal and chronic effects; the goal is to map risk to WHCR across their migratory range. Our work highlights the value of wetlands as indicators of ecosystem health and ecosystem services throughout the annual range of an endangered, wide-ranging migratory bird.

3.07.T.B-02 Identifying Hotspots of Chlorate and Perchlorate Exposure Using the Urban-Adapted Ring-Billed Gull

Matilde Baranton[1], Pauline Bellot[1], Coralie Turquois[1], Lounès Haroune[2], Raphaël Lavoie[3] and Jonathan Verreault[1] (1)University of Quebec in Montreal (UQAM), (2)University of Sherbrooke, (3)Environment and

Climate Change Canada (ECCC)

Chlorates and perchlorate are oxychlorine chemicals exhibiting oxidizing and reactant properties that are used in a wide range of industrial (e.g., paper production, pyrotechnics) and agricultural (e.g., pesticides, fertilizers) applications. They were shown to elicit toxicity; chlorates can induce oxidative stress, and both were reported to have endocrine-disrupting properties. Despite their widespread use, the emission sources, exposure pathways, and toxicological impacts in wildlife species spanning agro-urban habitats remain poorly characterized. This study aimed to identify the anthropogenic sources of chlorates and perchlorate in birds exploiting agro-urban habitats. The ring-billed gull (Larus delawarensis) breeding in the densely populated Montreal area (QC, Canada) exploits a mosaic of highly urbanized and agricultural habitats, making it an ideal sentinel species to address this objective. Thirty-three adult female and male gulls were equipped with miniature Global Positioning System dataloggers to track their movements for 72 h during the incubation period. Chlorate and perchlorate concentrations were quantified in plasma, liver, guano, and stomach content. Chlorates were detected in 91% of stomach content, 82% of liver, 65% of guano and 12% of plasma samples, with concentrations reaching up to 331 ng/g in guano. Perchlorate was found in 70% of guano, exhibiting the highest levels with a maximum of 10,667 ng/g, and 55% of liver samples, whereas it was not detected in plasma and stomach content. An integrated Exposure Index was calculated by summing concentrations across the four matrices for each compound. Behavioral modeling using Hidden Markov Models (HMM) showed that gulls spent 81% of their time at the colony, 12% foraging, and 7% in flight (transit to/from foraging sites). Foraging occurred preferentially in landfills (26%) and agricultural fields (22%). For chlorates, positive correlations were found between the Exposure Index and time spent in industrial areas and wastewater treatment plant facilities. No significant relationships were observed for perchlorate. Industrial and wastewater areas appeared to be significant chlorate exposure sources, despite the fact that only 16% of gulls visited these sites. Altogether, exposure in foraging sites may not be the only route; alternative pathways, such as inhalation while flying, warrant further investigation in these urban-adapted gulls.

3.07.T.B-03 Benzotriazole UV-Stabilizer Exposure in Ring-Billed Gulls From an Urban, Freshwater Harbour in Lake Ontario, Canada: Evaluating Contaminant Bioaccumulation and Potential Health Impacts

Kerry Schutten[1], Andre Morrill[2], Akshaya Chandrashekar[3], Zhe Lu[4], Janet Beeler-Marfisi[3], Jennifer Provencher[5] and Claire Jardine[3] (1)University of Calgary, (2)Environment and Climate Change Canada, (3)University of Guelph, (4)University of Quebec at Rimouski (UQAR), (5)Environment and Climate Change Canada (ECCC)

Plastic-associated contaminants, including benzotriazole UV-stabilizers (BZT-UVs), are receiving increased attention due to their environmental persistence, long-range transport, and potential to induce biological toxicity. However, little data is available regarding bioaccumulation and potential health impacts secondary to chronic BZT-UVs exposure in wildlife. We investigated the accumulation of 13 plastic-associated contaminants, including nine BZT-UVs, in 75 ring-billed gull (RBGU; Larus delawarensis) eggs collected in 2022 from the Hamilton Harbour in Lake Ontario, Canada. We evaluated the relationships between BZT-UVs exposure, gull body condition, trophic level, and renal and hepatic blood biochemistry variables. We detected at least one contaminant in 96 % of eggs, at least one BZT-UVs in 94.7 % of eggs, and UV328 in 92 % of eggs. We compared our results with American herring gull (Larus argentatus smithsonianus) eggs collected from the Hamilton Harbour in 2014 and detected a significantly higher concentration of UV328 in our samples. We

found no impact of trophic level on UV328 egg concentrations in our study population based on stable isotope analysis, and we did not detect a significant relationship between UV328 and female gull body condition. A significant positive relationship was identified between egg UV328 and uric acid concentrations in female RBGU, suggesting a possible relationship between UV328 exposure and impaired renal function in this population. No other relationships were identified between UV328 burden and selected hepatic biochemistry analytes. RBGU at this location are highly exposed to BZT-UVs, and RBGU eggs represent a non-invasive method for long-term monitoring of plastic-associated contaminants and their potential impacts.

3.07.T.B-04 Spatial Ecotoxicology in Motion: A Review of Movement, Stable Isotopes, and Contaminant Exposure in Wildlife

Christina Petalas[1], Sofia Higgs[2], Laurianne Richard[3], Anaïs Kerric[2], Raphaël Lavoie[4] and Kyle Elliott[1] (1)McGill University, (2)University of Quebec in Montreal (UQAM), (3)National Institute for Scientific Research (INRS), (4)Environment and Climate Change Canada (ECCC)

Recent advances in biologging, stable isotope, and contaminant analyses have expanded opportunities to investigate animal movement, foraging ecology, and contaminant exposure simultaneously. However, these data streams remain rarely integrated within individual studies, limiting mechanistic inference on contaminant acquisition across space and time. We conducted a systematic review of 162 peer-reviewed studies (1999–2026) to evaluate how movement ecology, stable isotope analysis, and contaminant monitoring have been combined in wildlife research. Metadata were extracted on contaminant classes, sampled matrices, isotopic applications, movement metrics, analytical approaches, and levels of data integration. The literature was strongly biased toward birds (70% of study-species records), with substantially fewer investigations of fish (15%) and mammals (13%). Mercury was the most frequently assessed contaminant class, occurring in 69% of study-species records, followed by other metals (27%), organochlorines (26%), lead (26%), flame retardants (19%), and PCBs (18%). Contaminant analyses were conducted primarily on non-lethal matrices, with feathers, hair, and other keratinized tissues (n = 144) and blood (n = 85) sampled most frequently. Stable isotope applications were dominated by bulk $\delta^{13}C$ and $\delta^{15}N$ analyses, while GPS was the most commonly used biologging technology. Multi-isotope approaches and advanced sensors such as accelerometers and video loggers remained comparatively uncommon. Despite growing use of these complementary tools, most studies applied biologging, stable isotopes, and contaminants in parallel rather than as fully integrated analytical frameworks. We identify major gaps in temporal alignment, individual-level sampling, and analytical integration, and propose a conceptual framework linking telemetry, stable isotope turnover, and contaminant exposure windows. Our synthesis provides practical recommendations for improving integration across data streams and strengthening inference on contaminant pathways and exposure mechanisms in wildlife.

3.07.T.B-05 Bridging Data Gaps in Terrestrial Insect Ecotoxicity Across Species and Experimental Variables

Tom Purucker[1], Cassandra Strauch[2], Gage Sachs[3], Matthew Etterson[1], Kristina Garber[1], Margaret Murphy[4], Holly Rogers[1], Sujatha Sankula[4], Keith Sappington[4] and Michael Wagman[1] (1)U.S. Environmental Protection Agency (US EPA), (2)Oak Ridge Institute for Science and Education (ORISE), (3)General Dynamics Information Technology, (4)US Environmental Protection Agency

Terrestrial insects provide critical ecosystem services, yet their vulnerability to pesticides remains poorly

characterized across taxa, endpoints, and test designs. We compiled an integrated terrestrial insect ecotoxicity database by curating and merging >50 years of data from USEPA's ECOTOXicology (ECOTOX) Knowledgebase and the Office of Pesticide Programs' Pesticide Ecotoxicity Database, yielding 120,034 records spanning 2,082 species and 2,262 chemicals. Nearly half of the records report mortality, though alternative measurement endpoints (e.g., navigation, oviposition behavior, thermal tolerance) have increased in recent years. The Western honey bee (Apis mellifera) is the most frequently tested species (18% of records). Using this dataset, we evaluated how organism size (weight), life stage (adult, larval), chemical grade (technical grade active ingredient, formulated end-use product), and exposure type (contact, oral) influence LD50 values. Body size and chemical grade were influential predictors: larger organisms had higher LD50s and formulated products were more toxic than technical-grade active ingredients. Exposure type had a minor effect, and life stage showed no consistent influence. Despite the large dataset, species sensitivity distributions and 5th percentile hazard concentration/dose (HC05) estimates were feasible for only 47 pesticides due to limited species coverage per pesticide, constraining broader interpretation of trends due to uneven data coverage. We further assessed how well A. mellifera represents the sensitivity of non-Apis pollinators and other terrestrial invertebrates across pesticide classes. A. mellifera generally exhibited median sensitivity relative to other taxa, but its variability across chemicals highlights substantial mode of action and species-level variability that has been linked to metabolic detoxication capacity, life history traits, and phylogeny differences. Collectively, this work delivers an accessible, reusable resource to support meta-analyses and provides an empirical basis for using A. mellifera as a surrogate, thereby strengthening terrestrial insect risk assessment by incorporating non-Apis data, applying taxonomic extrapolation or cross-species models where data are sparse, and supplying an initial basis for systematic literature reviews to better characterize risks for data-poor and listed species.

3.07.T.B-06 Temporal Trends of Contaminants in Northern Gannet Eggs From the Gulf of St. Lawrence (1969–2024)

Anna Reclus[1], Anais Fournier[1], Anaïs Kerric[2] and Raphael Lavoie[1] (1)Environment and Climate Change Canada, (2)Environnement and Climate Change Canada

Over the past five decades, numerous regulations have been implemented to reduce environmental emissions of persistent organic pollutants, including organochlorine pesticides (OCs) and per- and polyfluoroalkyl substances (PFAS), and metals. However, assessing their long-term effectiveness remains essential to understanding contaminant persistence in the environment. This study models temporal trends in contaminant concentrations in northern gannet (Morus bassanus) eggs collected on Bonaventure Island (Quebec, Canada) over a 55-year period (1969–2024). Eggs were analyzed for 20 OCs, 35 polychlorinated biphenyls (PCBs), 22 halogenated flame retardants (HFRs), 17 PFAS, and total mercury (Hg). Lipid content and stable isotopes of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) were measured. Results show OC and PCB concentrations declined by 85–90% from the early 1970s to the mid-1990s, demonstrating the effectiveness of regulatory actions. DDT-derived compounds, known to impair eggshell formation and reproductive success in birds, remained dominant OCs despite their regulations. HFRs, primarily polybrominated diphenyl ethers, increased up to the late 1980s, followed by a decline in the 1990s, reflecting their period of intensive use and subsequent restrictions. PFOS was the predominant PFAS, reaching a maximum in the mid-1990s before declining. However, estimated ecological half-lives for Σ17PFASs reached up to 60 years, and PFOS concentrations remained above toxicological thresholds for approximately three decades, indicating persistent risks for marine predators. Declines in replacement PFASs were less pronounced, suggesting the continued use of fluorinated alternatives that remain

less regulated. Reductions in organic contaminants were associated with regulations but also with voluntary industry phase-outs preceding formal restrictions. Mercury concentrations fluctuated over time, reflecting changes in anthropogenic sources, but declined by approximately 55% during the study period. Although regulatory actions have substantially reduced contaminant burdens in northern gannet eggs, most compounds remain detectable today. These findings highlight the importance of long-term monitoring for evaluating regulatory effectiveness and identifying ecotoxicological risks from both legacy and emerging contaminants in marine ecosystems.

Wildlife Ecotoxicology: Exposure, Accumulation and Effects

3.07.P-Tu045 Ecosystem Response to PFAS Production Shifts: Insights From Long-Term Multi-Matrix Tissue Monitoring and Non-Targeted Analysis in San Francisco Bay

Miguel Mendez[1], Ezra Miller[1], Diana Lin[1], Rebecca Sutton[1], Richard Grace[2], Yanan Chen[3], Carrie McDonough[3], Bernard Crimmins[4] and Jennifer Sun[1] (1)San Francisco Estuary Institute, (2)SGS-AXYS, (3)Carnegie Mellon University, (4)Clarkson University

Rapid responses to shifts in PFAS production and use over the past two decades have been documented in near-source systems and human populations, but regional ecosystem responses are much more variable. The San Francisco Bay (California, USA) is a large, highly urbanized estuary that reflects this complexity, with broad PFAS sources, use patterns, transport pathways, and bioaccumulation dynamics that drive variable ecosystem responses across sub-basins and compounds. The Regional Monitoring Program for Water Quality in San Francisco Bay (RMP) is an innovative collaborative effort of regulatory agencies and the regulated community that has used long-term contaminant monitoring in San Francisco Bay to inform management decisions since 1997. Long-term, multi-matrix tissue monitoring of PFAS conducted by the RMP since 2004 has revealed distinct spatial and temporal patterns of wildlife accumulation in response to shifts in the production and use of PFOS and other legacy PFAS. These data now serve as a baseline for the development of consumption advisories and regulatory thresholds. Additional non-targeted screening analysis via ultra high performance liquid chromatography ion mobility quadrupole time of flight mass spectrometry (UPLC-IMS-QToF-MS) has also been used to characterize the breadth of bioaccumulating PFAS classes, including novel PFAS. Here we present over a decade of data on PFAS accumulation patterns in marine mammals, fish, and bird eggs, together with a non-targeted screening analysis of harbor seal liver and fish muscle, to highlight the impacts of PFAS production shifts on this complex urban estuary.

3.07.P-Tu047 Accumulation and Temporal Trends (2002–2023) of BUVSs and SMCs in Blubber of Common Dolphins (Delphinus delphis) From Korean Coastal Waters

Hyeon Ryeong Kim[1], Jun Hwa Hong[1] and Hyo-Bang Moon[1] (1)Hanyang University

Benzotriazole ultraviolet stabilizers (BUVSs) are widely used in industrial and personal care products due to their ability to prevent light-induced degradation, while Synthetic musk compounds (SMCs) commonly are applied as fragrances in personal care products. Despite their widespread use, the ecological risks remain uncertain due to limited availability of data in wildlife, particularly in marine mammals. This study investigated accumulation patterns and temporal trends of BUVSs and SMCs in the blubber of common dolphins (Delphinus

delphis) from Korean coastal waters during 2002–2023 (n = 159) by gas chromatography coupled to triple quadrupole mass spectrometer (GC-MS/MS). Among BUVSs, UV-329 showed the highest concentrations and contribution, while HHCB was predominant among SMCs. Temporal trends were evaluated based on body length-adjusted concentrations. Total concentrations of BUVSs remained relatively stable throughout the monitoring period, while individual compounds showed contrasting trends. UV-326, UV-327, and UV-328 decreased significantly, whereas UV-329 increased, suggesting a shift in usage patterns in Korea. Total concentrations of SMCs significantly declined during monitoring period driven by decline of HHCB. The decline of UV-328, which was listed as persistent organic pollutants (POPs) in 2023, suggests that regulations are effective in the Korean water environment. However, the increase of structurally related BUVSs offset changes in total BUVSs concentration. These findings highlight the need for continued monitoring of UV-328 and other BUVSs to support the protection of the Korean marine environment.

3.07.P-Tu048 Contaminants in Female Belugas and Their Young in Two Beluga Populations, the Endangered St. Lawrence Estuary and Eastern Beaufort Sea Belugas (Delphinapterus leucas)

Lisa Loseto[1], Marie Noel[2], Katerina Colbourne[2], Fisheries Joint Management Committee[3], Tuktoyaktuk Hunters and Trappers Committee[4], Emilie Couture[5], Amila De Silva[6], Magali Houde[6], Jane Kirk[6], Ashley Elliot[2], Veronique Lesage[2], Stephane Lair[5], Cortney Watt[2], Jonathan Verreault[7] and Shannon MacPhee[2] (1)No Affiliation, (2)Fisheries and Oceans Canada, (3)Fisheries Joint Management Committee, (4)Tuktoyaktuk Hunters and Trappers Committee, (5)Canadian Wildlife Health Cooperative, Faculté de médecine vétérinaire, Université de Montréal, Saint-Hyacinthe, Québec, J2S 8H5, Canada, (6)Environment and Climate Change Canada (ECCC), (7)University of Quebec in Montreal (UQAM)

The beluga whale (Delphinapterus leucas), or qilalugak, with over 20 populations ranging throughout the circumpolar Arctic and some southern locations, is regarded as a sentinel species due to its high trophic level, long life, and cultural significance to the Inuit throughout Inuit Nunaat. Two populations, the endangered St. Lawrence Estuary (SLE) and the Eastern Beaufort Sea (EBS) belugas have some of the longest contaminant monitoring data sets associated with two very different management and monitoring programs. The opportunities to learn across populations have proven beneficial in strengthening our understanding of contaminant effects. Exposure to contaminants has been identified as one of the key threats impeding the recovery of the endangered SLE belugas and is a key priority for Inuvialuit harvesting EBS belugas. Recognizing exposure to contaminants occurs at early life stages through maternal transfer, we aim to characterize contaminants (PCBs, PAHs and PFAS) in beluga samples to better understand contaminant-associated health risks. Through the collection of SLE samples from washed up carcasses and EBS samples from traditionally harvested belugas, we have access to mother/fetus pairs (SLE: n = 3; EBS: n = 1), calves (SLE: n = 1; EBS: n = 1) and, for EBS, females of various reproductive statuses (early pregnancy (n = 2), late pregnancy (n = 2), recent parturition (n = 1), menopausal (n = 2), and immature (n = 2)). Despite a limited sample size, the matching mother/fetus pairs and inclusion of all reproductive statuses offers a unique opportunity to evaluate maternal transfer of contaminants of concern that affect beluga health early on in life. These results will provide an important opportunity to help inform conservation and contaminant mitigation measures.

3.07.P-Tu050 Skin as a Signal: Tracking Salinity Stress Through Lesions in Galveston Bay

Dolphins

Lola Renauer[1], Kristi Fazioli[2], Alyssa Quackenbush[3], Leslie Hart[4], Robert Young[5], Geoff Scott[6] and Vanessa Mintzer[7] (1)University of South Carolina, (2)Charted Marine Consulting; Galveston Bay Dolphin Research Program, (3)Galveston Bay Foundation, (4)College of Charleston, (5)Coastal Carolina University, (6)Univesity of South Carolina, (7)Galveston Bay Foundation, Galveston Bay Dolphin Research Program

Bottlenose dolphins (Tursiops spp.) are widely recognized as sentinels of coastal ecosystem health. In Galveston Bay, Texas, increasingly frequent freshwater influxes associated with extreme weather events are altering salinity conditions and stressing resident marine life. One emerging consequence is freshwater skin disease (FSD), characterized by skin lesions and physiological stress resulting from exposure to low-salinity environments.

Using data collected by the Galveston Bay Dolphin Research Program (2014-2019), we conducted a preliminary evaluation of the association between salinity variation and freshwater-related skin lesions in this population. Lesions were evaluated using the "Dolphin FRESH Protocol", a standardized photographic assessment method categorizing lesions into three distinct types (overgrowth, target-like, and light discoloration), enabling consistent and repeatable classification of FSD across individuals and time.

A preliminary evaluation of 47 individual dolphins resulted in 966 case assessments, defined as all photographs of an individual at a given point in time. After excluding 371 cases (38.41%) due to insufficient image quality, 595 cases remained. Of these, 114 (19.2%) were negative for freshwater-related lesions, 243 (40.8%) were suspected, and 238 (40.0%) were positive. Among positive cases, most were classified as low severity (scores 1-5; 55.9%), followed by medium (6-12; 48.9%), and high (>12; 1.3%). Across cases with both salinity and severity recorded (n = 324), higher salinity was associated with lower lesion severity (Spearman's $\rho = -0.404$, $p = 3.66e^{-}14$), suggesting a strong relationship between reduced salinity exposure and worsening skin condition.

In upcoming work, we will expand these analyses to include all 126 individuals sighted at least 15 times during the study period (~6,334 images). We will also address remaining gaps in salinity data through integration of additional datasets and more robustly quantify the relationships among salinity, water temperature, and lesion severity. Together, these efforts will enhance understanding of how changing salinity conditions influence visible health indicators in bottlenose dolphins and improve their utility as sentinels of coastal ecosystem change.

Disclaimer/Disclosure: Images obtained by the Galveston Bay Dolphin Research Program, NMFS MMPA Permit #18881

3.07.P-Tu051 Friend or Foe for Insect Survival? Neonicotinoids and Butenolide Insecticides in Flowers of Common Perennials and Natural Areas in Canada

John Elliott[1], Christine Bishop[2] and France Maisonneuve[3] (1)Environment and Climate Change Canada (ECCC), (2)Environment and Climate Change Canada (ECCC), (3)Environment and Climate Change Canada

Concern for the survival of pollinator insects and pollination of plants is often voiced among scientists and gardeners. 'Pollinator Gardens' are encouraged and purported to help bees and other insects survive in the Anthropocene. However, analysis of common perennial plants including Echinacea, Coreopsis and Sedum found several neonicotinoids (acetamiprid, imidacloprid, clothianidin) occurring in these flowers at concentrations above 2 to 5 ng/g and a butanolide Flupyradifurone at concentrations up to 146 ng/g. Given

application rates in nursery settings in Canada are much higher than in crop fields, these results are not unexpected although they may be surprising to the average well intended gardener. Furthermore, we found concentrations of these compounds are commonly found in suburban gardens, and sites as far as 200 m from crop fields. These results further demonstrate the ubiquitous occurrence of these systemic insecticides in the environment.

3.07.P-Tu052 Bioaccumulation of Mercury in Bald Eagle Nestlings From the Salish Basin of British Columbia, Canada – Spatial and Dietary Differences and Influences

John Elliott[1], Kate Fremlin[2], Sandi Lee[3] and Myles Lamont[4] (1)Environment and Climate Change Canada (ECCC), (2)Amaroq Wildlife Services, (3)Environment and Climate Change Canada, (4)Terrafauna

We investigated total mercury (THg) in bald eagles (Haliaeetus leucocephalus), and factors influencing exposure, across a marine-freshwater-terrestrial habitat gradient. Blood samples were collected from 91 nestlings (n = 64 nests), 2021 – 2023, at sites in the Salish Basin of southwest British Columbia, Canada, including the Fraser Valley, Delta, Burrard/Howe Sound, North/South Salish Sea, Southeast Vancouver Island, Thompson River, and a reference site on the west coast of Vancouver Island. Whole blood was used to analyze for total mercury and stable isotopes (δ13C, δ15N, and δ34S). Plasma was used for analysis of fatty acid methyl esters (FAME) to help distinguish among marine, aquatic and terrestrial diets. Isotope signatures and FAMEs had a clear spatial gradient with marine focused diets more prevalent on the outer west coast with higher δ13C, δ15N, δ34S and ∑Omega3 levels while transitioning to more terrestrial and freshwater diets inland with lower δ13C and higher ∑Omega6 levels. When averaged across sex, THg concentrations in nestling blood were generally higher at spatially separated sites in the Thompson River and South Salish Sea, with geometric mean concentrations of 1.2 ug/g dry weight (dw) and 0.54 ug/g dw, respectively, and lower in Burrard/Howe Sound and Southeast Vancouver Island with geometric mean concentrations of 0.12 ug/g dw and 0.16 ug/g dw, respectively. Linear mixed effects modelling indicated that δ15N and δ34S in nestlings generally increased with increasing THg concentrations in plasma ($p < 0.05$), whereas δ13C decreased with increasing THg concentrations ($p < 0.05$). We will further examine those relationships, and implications for identifying Hg sources. The lowest documented toxic effect concentrations in birds occurs at a blood-equivalent THg concentration of 0.2 ug/g wet weight; eight nestlings had THg concentrations in plasma above that threshold.

3.07.P-Tu053 Taking the Hair out of the Bear: Addressing Uncertainty in Wildlife Risk Assessment of Metals

Jennie Christensen[1], Lizzy Mos[2] and Scott Steer[2] (1)TrichAnalytics Inc., (2)Active Earth

Ecological risk assessments of wildlife species rely heavily on assumptions of body weight, food ingestion rates, dietary composition and bioavailability to estimate exposure to environmental contaminants. Compounding such assumptions results in highly uncertain and overly conservative risk estimates that impede decisive risk management. Can novel technologies using hair samples take some of this guesswork out of risk assessment? In this case study, we used food chain modelling in accordance with traditional ecological risk assessment methods to calculate dietary mercury exposure in free-ranging grizzly bears (Ursus arctos horribilis) and estimated ecotoxicological risk by means of a Hazard Quotient (HQ). We then compared our HQ results for this hypothetical bear to HQs based on a new approach method (NAM) using bear hair. As the hair is a

metabolically inert tissue, mercury incorporation rates could be calculated along the length of the hair strand, reflecting timely dietary exposure. A single bear hair was able to record mercury exposure concentrations throughout time with large seasonal variation apparent. Exposure also varied among individual bears due to dietary preference. Using bear hair thereby gives risk assessors the opportunity to derive a range of risk estimates rather than an integrated and uncertain average HQ for the species, as well as compare individuals within a species' population. This method contributes a non-invasive, efficient and reproducible approach for any hairy species, but particularly for species at risk that require protection at the level of an individual, in ecological risk assessments.

3.07.P-Tu054 Assessing Inflammatory Gene Expression in Two Marine Mammal Species Following Chronic Exposures to Three Plastic Additives

Sloane Hauck[1], Gabrielle Rupprecht[1], Jillian Weisse[1], Emma Stewart[1], Tom F. Schultz[1], Jason A. Somarelli[1] and Giuliana Mesarick[1] (1)Duke University

Annual global plastic pollution into marine systems is projected to more than double by 2030, increasing the vulnerability of marine mammals to macro-, micro-, and nanoplastics through entanglement and ingestion. The proliferation of plastics also subjects marine mammals to chronic exposure to plastic additives that leach into marine systems, where they can be ingested, inhaled, or absorbed dermally. Many plastic additives are known to exert toxic or sublethal effects on mammals that can inhibit development, reproduction, and immune and nervous system function; however, the impacts of most plastic additives remain unknown, and almost nothing is known about the effects of these additives on marine mammals. This study aimed to characterize sublethal effects of plastic additives through changes in inflammatory gene expression from chronic exposures and how changes in inflammation signal a reduction in organismal health to better understand the implications of chronic exposure at the population level. We hypothesized that chronic exposure to di-2-ethylhexyl phthalate (DEHP), diethyl phthalate (DEP), and perfluorooctanoic acid (PFOA), three plastic additives known to be found in marine mammal tissue and with known health outcomes in mammals, would increase the expression of pro-inflammatory cytokines over the study period, indicating higher baseline inflammation in both species from chronic exposure. Bottlenose dolphin (Tursiops truncatus) and Goose-beaked whale (Ziphius cavirostris) fibroblasts were subjected to chronic exposures (1, 2, and 6 months) at two concentrations of DEHP, DEP, and PFOA. Reverse transcription-quantitative polymerase chain reaction (RT-qPCR) was used to measure changes in gene expression of inflammatory cytokines relative to a housekeeping gene. Heightened baseline production of pro-inflammatory cytokines could impair animal recovery from illness or their ability to cope with other chronic stressors, such as sound pollution or altered habitat conditions due to climate change.

3.07.P-Tu055 How Urban Landscape Use Shapes Pesticide Exposure and Endocrine Responses in the Ring-Billed Gull

Pauline Bellot[1], Coralie Turquois[1], Lounès Haroune[2], Raphaël Lavoie[3] and Jonathan Verreault[1] (1)Environmental Toxicology and Health Research Centre (TOXEN), Department of Biological Sciences, University of Quebec at Montreal, Montreal, QC, Canada, (2)Sherbrooke Pharmacology Institute, University of Sherbrooke, Sherbrooke, QC, Canada, (3)Science and Technology Branch, Environment and Climate Change Canada, Quebec, QC, Canada

Agricultural intensification has increased wildlife exposure to complex mixtures of current-use pesticides,

raising concerns about their sublethal effects on animal health, including endocrine disruption. Omnivorous birds exploiting a mosaic of agro-urban habitats may be exposed through multiple pathways, ingestion of treated seeds, contaminated invertebrates, or agricultural runoff, yet the spatial determinants of this exposure in free-ranging individuals remain poorly understood. We investigated how landscape use shapes pesticide exposure and associated endocrine perturbation in the ring-billed gull (Larus delawarensis), an opportunistic omnivore frequently foraging in agroecosystems. Male and female gulls were captured in the Montreal area (QC, Canada) during the incubation period and GPS-tracked for five consecutive days to characterize individual foraging habitats. Upon recapture, blood, liver, stomach content, and feces were collected and analyzed for 56 current-use pesticides. Additionally, 25 plasma hormones were quantified to assess endocrine status. Mixed-effects models were used to examine relationships between habitat use, pesticide levels, and hormonal responses. Nine pesticides were consistently detected in ring-billed gull matrices. Summed pesticide concentrations increased significantly with the probability of presence of gulls in agricultural fields, while no such pattern emerged for other habitat types, including urban areas and the St. Lawrence River. Clothianidin, a neonicotinoid insecticide of particular concern for avian wildlife, was the most frequently detected compound and showed the strongest positive association with agricultural field use. Higher clothianidin concentrations were measured in birds sampled later in the incubation period, which was consistent with regional crop treatment schedules. The sum of pesticide levels was further significantly associated with both thyroid and sex hormone levels. Specifically, higher pesticide levels were positively correlated with androgen levels, suggesting potential inhibition of aromatase (enzyme converting androgens into estrogens), which would reduce estrogen synthesis with possible consequences for reproductive success. These findings suggest that foraging ecology and agricultural land-use practices combined can increase pesticide exposure risks in free-ranging birds.

3.07.P-Tu056 Turkey Toxins: An Eggs-Amination of Neonicotinoid Pesticides in Wild Turkeys

Ashley Morgan[1], Grace Perrin[1], Katie Riese[1] and Richard Gerhold[1] (1)University of Tennessee Knoxville

The Eastern wild turkey (Meleagris gallopavo, silvestris) is a well-known native inhabitant of Eastern North America, however, population declines over the last 20 years have been significant. The reasons for these declines are unknown but are suspected to be multifactorial including infectious disease, habitat loss, hunter-harvest dynamics, and environmental contaminant exposures. Furthermore, the impacts of these factors on reproduction and hatching success are also concerning for recruitment. The purpose of this study is to investigate the concentration of neonicotinoid pesticides and associated metabolomic shifts in opportunistically collected wild turkey eggs with hatch failure. Egg fertility assessments are conducted along with neonicotinoid quantification and metabolomics via LC/MS on both the albumen and yolk segments. Differential metabolite analysis reveals significant differences between fertile eggs and non-fertile eggs as well as associations with certain neonicotinoid concentrations. Metabolites of interest include those indicative of B6 vitamin deficiency, of which insects are the best natural sources in wild turkey diets. This may indicate that wild turkeys foraging in areas with higher neonicotinoid pesticide use may be deficient in insect-linked nutrients. These and other metabolic changes related to neonicotinoids provide insight into mechanisms of impact at both the individual and population levels. These data inform regulations on neonicotinoid use, supplemental feeding of wild turkeys, and the broader ecosystem impacts of third-generation pesticide use.

3.07.P-Tu057 Modified Northern Bobwhite (Colinus virginianus) Reproduction Studies To Assess Potential Exposure Scenarios Representative of Pesticide Treated Seed

Jonathan Maul[1], Helen Thompson[2], Diana Temple[3], Steven Kragten[4], Rowan Hanson[2], Eamonn Farrelly[2], Mike Pocock[5] and Pria Mahabir[5] (1)Syngenta Crop Protection LLC, (2)Syngenta Ltd, (3)Eurofins EAG Agroscience, LLC, (4)Syngenta Agro GmbH, (5)Syngenta Crop Protection AG

Registration of pesticides often require short and long-term (acute and chronic) avian studies to generate toxicity endpoints used in ecological risk assessments. The current regulatory avian reproduction study was designed primarily for assessment of molecules that are persistent and potentially bioaccumulative. This is evidenced in the exposure guideline which includes multiple weeks of dietary exposure. Many modern agricultural chemicals have very low environmental persistence and often are quickly metabolized. The technology of treating seeds is a growing agricultural practice that involves a very short wildlife exposure window, yet current risk assessments often utilize endpoints based on a longer exposure (e.g., 4.7x longer in the present example study). In this study we embedded a short-exposure treatment level within a standardized long-term avian reproduction study to simulate exposures to seed treatment. A study group with a dietary exposure of 20 ppm for 20 weeks had significantly reduced egg shell thickness and eggs cracked / eggs laid. For the same concentration (20 ppm) over an exposure period of only 4 weeks, egg shell thickness and eggs cracked / eggs laid were not different from the control group. This work demonstrates that avian reproductive response variables can be highly dependent on the length of dietary exposure and that the magnitude of an effect from a control response can follow an exposure time-integrated response relationship. Thus, current laboratory-based methodology for assessing chronic reproductive risks to birds is likely contributing to highly conservative endpoints that may not be appropriate for use in pesticide seed treatment risk assessments. We recommend either conducting modified avian tests with time-varying exposures or use of mechanistic models that utilize extracted subsets of data from current guideline studies. These approaches could lead to appropriate reproduction endpoints that reflect environmentally realistic seed treatment exposures and ultimately be used to generate accurate ecological risk assessments for seed treatment uses.

3.07.P-Tu058 How Much Does Oxidative Stress Contribute to Effects on Fish Embryos Exposed to Oxygenated PAHs?

Yuya HOJO[1], Saichiro Yokoyama[2], MIRAI UCHIMURA[1], Emiko Kokushi[1], Masatoshi Yamasaki[1] and Seiichi Uno[1] (1)Kagoshima University, (2)Kagoshima university

Oxygenated polycyclic aromatic hydrocarbons (OPAHs) have attracted attention as the air pollutants. They are also widely detected from aquatic environments and then raising concerns about the exposure effects, which are spinal curvature, cardiac edema, and craniofacial defects in Japanese medaka embryos and hatched larvae. Oxidative stress (OS) is considered one of the key triggers for developmental effects in fish embryos. In previous study, it has been shown that OPAH exposures cause OS during embryo development. However, the involvement of OS in toxicities induced by OPAHs remains unclear. We aimed to reveal toxic mechanisms of OPAHs originated with OS. Usually, OS is relieved by antioxidants. Ascorbic acid (AsA) accomplishes an important role as antioxidants and could protect from damage induced by OS. We predicted that the effects derived from excessive OS generated by OPAHs exposure might cause AsA shortage in the fish embryos. Therefore, we prepared AsA-deficient embryos of Japanese medaka (Oryzias latipes) and exposed them to 1,2-benzanthoraquinone (BAQ), which is one of the most ubiquitous OPAHs in environment.

As a result, AsA levels in deficient embryos significantly decreased to approximately one-twentieth of those in normal embryos. In addition, the induction rates for mortality and several effects increased with degree of AsA deficiency. Oxidative stress levels were not difference in low exposure group. Meanwhile, those in high exposure group were significantly higher compared to solvent control group. In contrast, spinal curvature was observed in up to approximately 20% of hatched larvae even in the control groups, suggesting that this symptom might not directly associated with oxidative stress. These results suggest that some toxic effects induced by BAQ are induced by excessive oxidative stress.

Disclaimer/Disclosure: This work was supported by Grants-in-Aid for Scientific Research, Japan (18K14522)

Wildlife Ecotoxicology: Exposure, Accumulation and Effects

3.07.V-01 Green Around the Gills: Investigating the Interactive Effects of Copper Exposure and Immune Stimulation in Goldsinny Wrasse (Ctenolabrus rupestris)

Sidney Martin[1], Vincent Mélançon[2], Juliane Vigneault[3], Ivan Cadonic[1], Maryane Gradito[4], Eirik Åsheim[5], Rachel Morgan[6], Dominique Roche[7], Sandra Binning[2] and Tamzin Blewett[1] (1)University of Alberta, (2)University of Montreal, (3)University of Quebec at Rimouski, (4)Deakin University, (5)Swedish University of Agricultural Sciences, (6)University of Bergen, (7)Social Sciences and Humanities Research Council of Canada

Wild animals routinely experience biotic (e.g. predator-prey interactions, competition) and abiotic (e.g. temperature, pollution) stressors that can affect their physiology and behaviour, and ultimately their fitness. For example, aquatic organisms commonly encounter pathogens that can result in an energetically costly upregulation of the immune system. While pathogenic infections are stressful in isolation, organisms are faced with these infections in conjunction with other environmental stressors, such as toxicant exposure. Copper (Cu) is a common environmental toxicant in aquatic ecosystems, and its anthropogenic use in pesticides, antifouling agents, and green technology has resulted in heightened concentrations within aquatic systems. Exposure to Cu alone can result in ionoregulatory challenges, immune system impairment, metabolic disruptions, and even mortality. Cu toxicity has been well studied in isolation, but not in fish also experiencing immune stimulation due to pathogenic infections. Understanding how pathogenic infections and pollution may interact and effect aquatic organisms is critical given their increasing prevalence due to environmental change. Using goldsinny wrasse (Ctenolabrus rupestris), we conducted two experiments to investigate the interactive effects of Cu exposure and immune stimulation on fish physiology and behaviour. Wrasses were exposed to Cu for 96-hours at either control (0 µg/L), low (125 µg/L), or high (500 µg/L) concentrations. Fish were administered either a control treatment, via saline injection, or a lipopolysaccharide injection to stimulate the immune system. Injections were administered either before (experiment 1) or after (experiment 2) the Cu exposure to allow us to observe how an ongoing infection affects Cu exposure and accumulation, as well as vice-versa to see how a previous Cu exposure alters the organisms' reaction to an infection. Behavioural trials after each experiment measured activity levels and exploration behaviour, in addition we dissected tissues (liver, gill, intestine, spleen) to assess bioaccumulation. Our results help elucidate how Cu accumulation and behaviour may be altered when a marine fish experiences both toxicant exposure and pathogenic infections, providing important information on how fish respond when faced with these simultaneous stressors.

Wildlife Toxicology: Evaluating Exposure and Potential Effects of Emerging and Legacy Contaminants

3.08.T-01 Contaminant Distribution Across the Polar Bear Brain: Integrating Trace Elements, PFAS, and Selenium Speciation in a Canadian Arctic Top Predator

Sofia Paciello[1], Marc Amyot[1], Michael Kwan[2], Jean-François Pflieger[1], Nejumal Kannankeril Khalid[1], Sebastien Sauve[1], Ariane Barrette[3], Pierre Ayotte[3], Kevin Wilkinson[1] and Maikel Rosabal[4] (1)University of Montreal (UdeM), (2)Nunavik Research Centre, (3)Laval University, (4)University of Quebec in Montreal (UQAM)

Polar bears (Ursus maritimus) from Nunavik (Canadian Arctic) are among the most contaminated wildlife globally, yet the neurological implications of their contaminant burden remain poorly characterized. No prior study has simultaneously examined trace elements, per- and polyfluoroalkyl substances (PFAS), selenium (Se) speciation, and mercury selenide nanoparticles (HgSe NPs) across multiple brain regions in Canadian polar bears. Seven brain regions were dissected from 12 individuals and analyzed for total mercury (THg), methylmercury (MeHg), trace elements, PFAS, and Se speciation including selenoneine and selenolipids, using inductively coupled plasma mass spectrometry (ICP-MS)-based techniques coupled to various separation methods, and single-particle time-of-flight ICP-MS for nanoparticle characterization. Analyses focused on the contrast between blood-brain barrier (BBB)-protected regions and the pituitary gland, partially located outside the BBB.

The pituitary gland exhibited the highest THg and Se concentrations across all regions. Its atypically low MeHg fraction (~46% of THg, vs. >80% elsewhere) reflects in situ demethylation and Hg sequestration through HgSe NPs, identified here for the first time in polar bear brain tissue. Se-to-Hg molar ratios exceeded 1:1 across all samples. Selenomethionine (~17–23% of total Se) dominated across BBB-protected regions, while selenolipids were detected in cortical and cerebellar areas but absent from the brainstem and hypothalamus. Selenoneine showed highest concentrations in the hypothalamus (mean 0.24 μg/g), suggesting region-specific antioxidant mobilization linked to local Hg exposure.

PFAS accumulation in BBB-protected regions was driven by lipid and protein contents, with some long-chain perfluoroalkyl carboxylates accumulating preferentially in protein-rich areas such as the cerebellum. Systemic PFAS–metal co-occurrence analysis revealed negative associations between medium- and long-chain PFAS and essential metals, consistent with competitive protein-binding, and positive associations between perfluorooctane sulfonate and trophic co-exposure markers arsenic and cadmium. These findings provide the first integrated characterization of multi-contaminant dynamics across the polar bear brain, highlighting the pituitary gland as a critical site of accumulation and Se-mediated detoxification, and identifying region-specific neurotoxicological vulnerability in an Arctic top predator.

3.08.T-03 Per- and Polyfluoroalkyl Substance (PFAS) Contamination in North Atlantic Odontocetes: Comparisons Among Species, Regions, and Timepoints

Kiah Lee[1], Marina Arregui[2], Rossana Bossi[2], Rune Dietz[2], Christian Sonne[2], Jens Søndergaard[2], Pierre Blévin[3], Steven Ferguson[4], Kailee Hopkins[1], Jeremy Kiszka[5], Ámbar Maldonado Rodriguez[1], Cory Matthews[4], Bjarni Mikkelsen[6], Audun Rikardsen[7], Cortney Watt[4] and Melissa McKinney[1] (1)McGill University, (2)Aarhus University, (3)Akvaplan NIVA, (4)Fisheries and Oceans Canada, (5)Florida International University, (6)Faroe Marine Research Institute (FAMRI), (7)UiT The Arctic University of Norway

Per- and polyfluoroalkyl substances (PFAS) are synthetic organic contaminants of environmental concern found at high concentrations in long-lived and upper trophic-level consumers, including toothed cetaceans (odontocetes). Yet, large knowledge gaps on PFAS accumulation in odontocete species remain, including how PFAS vary across broad spatial and temporal scales in the North Atlantic Ocean. We measured 38 individual PFAS in muscle and/or skin from fourteen odontocete species (n = 259 individuals) sampled opportunistically in local harvests or from biopsies collected between 2010 and 2025 in seven regions of the North Atlantic, including Atlantic Canada (AC), Eastern Canadian Arctic (ECA), West and East Greenland (WG and EG), Faroe Islands (FI), Northern Norway (NN), and St. Vincent and the Grenadines (SVG) in the Caribbean Sea. To quantitatively compare concentrations across tissue types, skin PFAS concentrations were converted to muscle concentrations using a predictive equation generated from paired skin-muscle samples from 29 individuals. Subsequent interspecific and geographic comparisons showed total PFAS concentrations in muscle ranged from 2.10 to 153 ng/g wet weight. Sperm whales (sampled in NN, ECA, and EC), as well as killer whales (sampled in EC and EG), exhibited the highest total PFAS concentrations, while narwhals (sampled in WG and ECA) and belugas (sampled in ECA) showed the lowest. FI odontocetes, as well as EC long-finned pilot whales and EG narwhals, showed intermediate PFAS concentrations, which did not differ significantly from odontocetes in other locations. PFAS concentrations in SVG odontocetes are currently being investigated. In addition, historic archived samples from the 1970s – 1980s are being analyzed and compared to recently collected samples to evaluate long-term trends in PFAS accumulation. The influence of foraging habitats and relative trophic level on PFAS accumulation using bulk and compound-specific amino acid stable isotope analyses is also being investigated. Findings to date demonstrate that within the northern portion of the North Atlantic Ocean, PFAS are elevated in upper trophic level odontocetes such as sperm and killer whales, relative to other species, and results also suggest higher PFAS exposure in EG odontocetes relative to those in FI and WG, demonstrating variability in PFAS concentrations across species and regions of the North Atlantic Ocean.

3.08.T-04 Anticoagulant Rodenticides in Aquatic Systems: Exposure, Bioaccumulation, and Toxicity in Pacific Salmon

Melissa Driessnack[1], Lillian Pavord[1], Aaron Shiels[2], John Stark[1] and Jenifer McIntyre[1] (1)Washington State University, (2)USDA APHIS

Anticoagulant rodenticides (ARs) are widely used contaminants that have traditionally been studied in terrestrial wildlife, where secondary poisoning of birds and mammals is well documented. However, growing evidence indicates that ARs can enter aquatic ecosystems through multiple pathways, including island eradication programs, sewer baiting, agricultural runoff, and other urban and rural applications. Despite increasing detections in aquatic environments, the ecological risks of ARs to fish remain poorly understood. To address this knowledge gap, we evaluated the accumulation and toxicity of two commonly used ARs,

brodifacoum (BDF) and diphacinone (DPN), in Pacific salmon across a range of study designs. Early life-stage coho (Oncorhynchus kisutch) and pink (O. gorbuscha) salmon were exposed to AR-containing bait pellets during embryo and alevin development. Additionally, juvenile coho were exposed through trophic transfer using mealworms (Tenebrio molitor) reared on AR-containing bait pellets. Survival, developmental abnormalities, tissue residues, clotting time, and biochemical biomarkers were assessed during the different exposures.
Across all studies, brodifacoum exposure resulted in significant increases in mortality, hemorrhaging, and other impacts depending on the life-stage (e.g., craniofacial abnormalities in alevin), whereas diphacinone produced comparatively limited effects. Tissue analyses confirmed AR accumulation and demonstrated changing residue dynamics across developmental stages and growth periods. Juvenile feeding studies further demonstrated trophic transfer of ARs and increased mortality (~20%) following chronic dietary exposure to brodifacoum (14- and 30-day feeding trials). Collectively, these findings indicate that ARs represent an underrecognized threat to aquatic wildlife and that risks extend beyond the terrestrial vertebrates that have historically been the focus of ecological risk assessments. The observed bioaccumulation, developmental toxicity, and trophic transfer highlight the need to incorporate aquatic food webs and fish species into future evaluations of AR environmental impacts.

3.08.T-05 Multi-Omic Signatures of Contaminant Exposure in Barren-Ground Caribou

Eric Wootton[1] (1)McGill University

Barren-ground caribou (Rangifer tarandus) are a defining Arctic herbivore and, through a lichen-dominated winter diet, integrate a continent-scale atmospheric contaminant signal in a single trophic step. Many North American herds have declined sharply in recent decades, yet contaminant work has focused on body burdens of contaminants, with little attention to the molecular consequences of exposure in free-ranging animals. We investigated each herd's total contaminant burden and multiple measures of biological response.

We collected tissues from 108 caribou across five herds (Beverly, Bluenose-East, Porcupine, Qamanirjuaq, and Tuktoyaktuk Peninsula), with lichen from four locations. In each animal we quantified a broad panel of contaminants spanning multiple chemical classes, including targeted analyses and non-targeted high-resolution mass spectrometry. Exposures were paired with liver gene expression (RNA sequencing) and genome-wide DNA methylation. Correlated contaminants were grouped into co-accumulation modules and related to molecular response using linear mixed models controlling for relatedness, age, sex, season, and climate.

Herd identity was the dominant axis of exposure: roughly 90% of compounds differed significantly among herds, indicating that a single pan-range exposure profile does not describe these populations. Of all the co-accumulation patterns examined, a single module produced a markedly stronger biological response than the others, driving the largest number of enriched liver pathways and region-level methylation changes, with elevated immune activation and reduced fatty-acid metabolism consistent with physiological stress. Two methylation sites survived stringent outlier-robust filtering; both fall in repetitive DNA unique to the caribou lineage and absent from other mammals, representing, to our knowledge, the first candidate molecular biomarkers of contaminant exposure reported in wild caribou.

These results reframe cumulative contaminant impacts as herd-specific exposure profiles rather than one shared

stressor, and show that coordinated contaminant mixtures, rather than single compounds, leave the clearest molecular fingerprint on caribou biology.

3.08.T-06 Associations Between Depletion of Vitamins A, E, and B1 (Thiamine) and Legacy Organochlorines and Polyfluoroalkyl Substances (PFAS) in Pre-Fledgling Double-Crested Cormorants of the Great Lakes

Keith Grasman[1], Drew VanWoerKom[2], Mandy Annis[3], Carly Eakin[3], Donald Tillitt[4] and James Ludwig[5]
(1)Calvin University and Wings Over Water Research Institute, (2)Calvin University, (3)U.S. Fish and Wildlife Service, (4)U.S. Geological Survey, (5)Consultant

Vitamins A, E, and B1 (thiamine) are useful biomarkers for health effects in wild birds as they play various roles in vision, immunity, antioxidant defenses, metabolism, development, and/or growth. Polychlorinated biphenyls (PCBs) have been associated with lower vitamin A, including in Great Lakes waterbirds. Pollutants causing oxidative stress might alter vitamin E. Thiamine deficiency has been found in Great Lakes salmonids and fish-eating birds elsewhere. This study investigated whether vitamins A, E, and B1 in blood differed in double-crested cormorants (Nannopterum auritum) at/near highly contaminated Great Lakes Areas of Concern (AOCs) compared to less contaminated sites and whether vitamins were associated with organic contaminants. Vitamins were measured in 355 pre-fledglings at 16 colonies across the Great Lakes in 2016 and 15 sites in 2017. Plasma vitamin A was 38-42% lower and vitamin E 45-49% lower at colonies in/near AOCs compared to nonAOCs. Thiamine vitamers in whole blood were lower in/near AOCs compared to nonAOCs: 49-70% lower for thiamine, 24-36% for thiamine diphosphate (TDP), and 39-58% for sum T (thiamine + TDP + thiamine monophosphate [TMP]). PCBs, dichlorodiphenyldichloroethylene (DDE), sum polyfluoroalkyl substances (PFAS; measured 2017 only), and sum perfluorosulfonic acids (PFSAs) were elevated in cormorant plasma (pooled by site and year) in/near AOCs. Sum perfluorocarboxylic acids (PFCAs) were elevated at nonAOCs. PAHs showed no difference between AOC groups. Vitamin A had very strong negative associations with dioxin-toxic equivalents attributable to coplanar PCBs (measured 2016 only), sumPFAS, and sumPFSAs (Jonckheere trend tests). Vitamin E showed very strong negative associations with PCBs (both years), coplanar PCB TEQs, sumPFAS, and sumPFSAs and moderate to strong negative associations with PAHs and DDE (both years). SumPFCAs showed very strong positive associations with both vitamins. Thiamine and sum T had negative associations with sumPCBs (both years) and PCB TEQs, DDE (both years), sumPFAS, and sumPFSAs. TDP had negative associations with sumPCBs, sumPFAS, and sumPFSAs. PAHs had negative associations with thiamine (both years) and with TDP and sum T (in 2017). SumPFCAs showed very strong positive associations with thiamine, TDP, and sum T. This study of vitamin biomarkers demonstrated depletion of vitamins A, E, and B1 in cormorants at/near AOCs and many statistical associations with specific organic contaminants.

Wildlife Toxicology: Evaluating Exposure and Potential Effects of Emerging and Legacy Contaminants

3.08.P-Th033 Tools To Assess Risks of Polychlorinated Biphenyls to Mink: Relative Potency Factors, Dose-Response Analysis, and Diet-to-Tissue Extrapolation

Phyllis Fuchsman[1], Kyle Fetters[1] and Shuo Yu[1] (1)Ramboll

Effects of polychlorinated biphenyls (PCBs) on reproduction of American mink (Neogale vison) are well studied and highly variable. We explored methods to reconcile dose-response relationships across studies through meta-analysis, accounting for relative potency and bioaccumulation potential of critical PCB congeners. Data were sufficient to support dose-response analyses based on PCB concentrations in mink diet and liver tissue. We also developed bioaccumulation regressions to extrapolate congener concentrations from diet to liver, where liver analyses were not performed. The best dose-response model fit was obtained by expressing exposures on a liver toxicity equivalence (TEQ) basis, using 2022 World Health Organization toxicity equivalence factors, including TEQ contributions for PCBs only (i.e., excluding polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans), and combining studies with measured liver data and studies requiring estimated liver concentrations. This model yielded 20% and 50% effect concentrations (EC20 and EC50) of 24 and 40 ng TEQ/kg liver wet weight (ww), respectively, for effects on the number of surviving offspring per mated female mink. We then used bioaccumulation regressions to back-calculate dietary total PCB concentrations equivalent to the liver ECs, for various representative PCB mixture compositions. The EC20-equivalent dietary concentrations ranged from 0.34 mg/kg to 3.3 mg/kg ww based on representative PCB fingerprints from environmental fish tissues and common Aroclor formulations, ranging as high as 26 mg/kg ww for the less widespread Aroclor 1268. This assessment provides a robust basis for toxicity reference values (TRVs) that can be customized based on site-specific PCB composition. The resulting TRVs can be applied to site-specific PCB exposure estimates and considered along with other lines of evidence, if available, to understand risks to mink populations.

3.08.P-Th034 Evaluating PFAS Risks to Birds Using Food Web Modeling and Risk Based Threshold Concentrations in Biota

Jean Zodrow[1], Elizabeth Nichols[1], Jennifer Arblaster[1] and Jason Conder[1] (1)Geosyntec Consultants, Inc.

in Biota

Jeanmarie Zodrow, Elizabeth Nichols, Jennifer Arblaster, and Jason Conder

Food web models can be a useful tool for ecological risk assessments (ERAs), as the collection and analysis of chemicals in biota at contaminated sites is not always practical and/or feasible, especially in the early stages of site investigation. Models can help identify when biota collection may not be needed, especially for sites that are less contaminated, as biota collection is difficult, time consuming, expensive, and may require ethical and regulatory considerations. Recent validation efforts for aquatic and terrestrial food web models compared model predicted concentrations of per- and polyfluoroalkyl substances (PFAS) in biota to measured concentrations in plants, invertebrates, and fish obtained from case studies. The validation results generally showed good agreement between modeled and measured concentrations of PFAS in biota, with some tendency for the model to overpredict concentrations in biota. An additional analysis was conducted to evaluate the accuracy with regards to predicting potential ecological risks based on dietary tissue concentrations protective of birds. For

this evaluation, modeled and measured concentrations of perfluorooctane sulfonic acid (PFOS) in earthworms and forage fish were compared to terrestrial invertivore and the aquatic piscivore risk-based threshold concentrations. PFOS was selected because of the prevalence in biota samples from the case study sites, and the availability of avian toxicity values for PFOS (McCarthy et al., in press). No observed adverse effect level (NOAEL) and low adverse effect level (LOAEL) risk-based dietary tissue concentrations (RBTCs) for PFOS were calculated for generic terrestrial invertivore and aquatic piscivore avian receptors. Overall, in 99% of the NOAEL and LOAEL evaluations, the model prediction of risk to avians was aligned with the measured risk, or the model prediction was over-protective, indicating a risk potential to avians when there was none. This is a reasonable level of confidence to use the model predictions to inform the need for sampling at a site. The validation effort conducted in this study demonstrates food web model predictions of PFAS concentrations in biota can be confidently used as a tool in ERAs.

3.08.P-Th035 PFAS Exposure and Effects in Shorebirds: Integrating National Egg Monitoring With a Controlled Egg-Injection Study

Robert Kesic[1], Christy Morrissey[1], Kirsty Gurney[2] and Markus Brinkmann[1] (1)University of Saskatchewan, (2)Environment and Climate Change Canada (ECCC)

Shorebirds may be particularly vulnerable to contaminant exposure because they occupy aquatic-terrestrial interfaces, utilize wetlands and agricultural habitats that receive contaminant inputs, and undertake long-distance migrations that connect ecosystems across broad geographic scales. Despite increasing concern regarding environmental contaminants in birds, little is known about the effects of perfluoroalkyl substances (PFAS) on shorebird development, physiology, and immune function.

We combined a national-scale monitoring program with a controlled egg-injection experiment to evaluate PFAS exposure and sublethal effects. Killdeer (Charadrius vociferus) eggs were collected from breeding sites in Saskatchewan and incubated under controlled laboratory conditions. Eggs were assigned to one of four treatments consisting of a vehicle control (DMSO) and three perfluorooctane sulfonate (PFOS) exposure concentrations (11 ng/g, 62 ng/g, and 200 ng/g ww), representing environmentally relevant contaminant burdens observed in Canadian bird eggs. Embryonic development, hatchability, growth, behaviour (e.g. righting reflex), oxidative stress (hydrogen peroxide, catalase, oxidized and reduced glutathione), and immune function (leukocyte coping capacity assay) were assessed from hatch through 21 days post-hatch and will be presented. We also measured PFAS concentrations in killdeer eggs from the Pacific, Prairie, Central, and Atlantic regions of Canada to characterize spatial variation in exposure. Preliminary PFAS data from northward-migrating shorebirds at Chaplin Lake, SK revealed elevated PFOS concentrations in sanderling plasma (mean = 30.3, range = 0.4-110 ng/g ww). Notably, short-chain PFCAs, such as PFBA, were also detected at relatively high concentrations in some sanderlings (mean = 1.83, range = nd - 8.3 ng/g ww) and were confirmed using high resolution mass spectrometry, suggesting that benthic foraging and sediment-associated exposure pathways may represent an important source of short-chain PFCAs in Arctic-breeding shorebirds.

This study represents one of the first controlled toxicological assessments of PFAS effects in a wild North American shorebird species. Findings will support ecological risk assessments and contribute to ongoing efforts to understand the consequences of PFAS in migratory birds.

3.08.P-Th036 Temporal, Spatial and Interspecific Trends of Perfluoroalkyl Substances (PFAS) in Atlantic Canada Seabird Eggs (1972-2022)

Jonathan Sangiovanni[1], Raphaël Lavoie[2] and Margaret Eng[2] (1)McGill University, (2)Environment and Climate Change Canada (ECCC)

Long-term seabird egg monitoring programs are useful tools for assessing contaminant trends in marine environments. For persistent bioaccumulative contaminants like certain per- and polyfluoroalkyl substances (PFAS) that have been the subject of national and international regulations and voluntary phaseouts, this historical data can be used to evaluate policy effectiveness and identify spatial and species-specific risks to wildlife health. The objectives of this study were to assess 1) long-term temporal trends of PFAS in Atlantic Canada seabird eggs 2) spatial trends of PFAS across Atlantic Canada, and 3) intra- and interspecific variations in PFAS burdens and patterns of dietary tracers (δ15N and δ13C) in eggs. Eggs from four species, American herring gulls (Larus smithsonianus), Atlantic puffins (Fratercula arctica), double-crested cormorants (Nannopterum auritum), and Leach's storm-petrels (Hydrobates leucorhous), were collected every 4 years between 1972 and 2022 from 10 different locations spanning four provinces (QC, NB, NS, NL) and archived at the National Wildlife Specimen Bank (Ottawa, ON). Four perfluorosulfonic acids (PFSAs) and 13 perfluorocarboxylic acids (PFCAs) were retrospectively analyzed in egg pools (n = 5 eggs per pool, 3 pools per species/site/year). Across all species, we found increasing ∑17PFAS trends from 1972 (range: 5.9 – 7.9%/year), followed by decreasing trends since the mid-1990s (3.9 – 5.4%/year). PFSAs declined earlier (5.1 – 7.1%/year since 1992 – 1998) than PFCAs (4.9 – 9.4%/year since 2001 – 2007). ∑17PFAS patterns varied by species and location. For example, in gulls, the most remote colony had the highest mean ∑17PFAS (Sable Island: 119.3ng/g), whereas in puffins the most remote colony had the lowest (Gannet Island: 45.1 ng/g). PFAS profiles varied by species, with cormorants accumulating more long-chain PFSAs, puffins more long-chain PFCAs, and petrels more short-chain PFCAs. However, across all species, perfluorooctane sulfonic acid (PFOS) was consistently the most abundant congener. Across all years and locations, species differences in ∑17PFAS were significant (cormorant > puffin > gulls ≈ petrel). The same order was observed for δ15N as an indicator of trophic position. Puffin and petrel had the lowest δ13C, suggesting more marine foraging habits. Results appear to temporally align with voluntary phase-outs and international and national regulations of PFAS, corroborating their effectiveness.

3.08.P-Th037 Behavioural and Sub-Lethal Effects of Microplastic Exposure in Key Coastal Macroinvertebrates

Zaib Ullah[1], Aaron Schultz[1], Ty Matthews[1], Chi Le[2] and Kay Critchell[1] (1)School of Life and Environmental Sciences, Faculty of Science Engineering and Built Environment, Deakin University, VIC, Australia, (2)School of Science, Edith Cowan University, WA, Australia

Microplastics are pervasive contaminants in coastal ecosystems, yet their sub-lethal effects on beach-associated macroinvertebrates remain poorly understood. This study examined whether environmentally relevant concentrations of polypropylene and polystyrene microplastics alter behavioural performance in two ecologically important coastal taxa: sandhoppers (Talitridae) and brown kelp beetles (Tenebrionidae).

Macroinvertebrates were exposed to three microplastic concentrations (0.25, 0.50, and 1.00 mg g^{-1} sediment) and a control treatment across four exposure durations (1, 7, 14, and 21 days) under controlled laboratory

conditions. Behavioural endpoints, including flipping time, latency to first jump, jump frequency, jump height, burrowing time, distance moved, and velocity, were quantified using live video analysis and EthoVision XT software. Internalised microplastics were recovered using a soft digestion protocol to assess particle ingestion and retention.

Microplastic exposure resulted in measurable behavioural alterations in both taxa, including impaired locomotion, delayed burrowing responses, and reduced jumping performance, with effects generally increasing across exposure duration and concentration. Species-specific responses were also observed, indicating varying sensitivities to polymer exposure. Ingested particles were successfully recovered from exposed organisms, confirming microplastic uptake under experimental conditions.

These findings demonstrate that chronic exposure to environmentally relevant microplastic concentrations can disrupt key behavioural functions linked to predator avoidance, mobility, and sediment interactions in coastal macroinvertebrates. This study provides important evidence for understanding the ecological consequences of microplastic pollution on beach ecosystem functioning and highlights the need to incorporate sub-lethal behavioural responses into future coastal ecotoxicological risk assessments.

Disclaimer/Disclosure: This research work was partially supported by the Holsworth Wildlife Research Endowment from the Ecological Society of Australia (ESA).

3.08.P-Th038 Ammunition for Hunting Waterfowl: Time To Review Ecological Risk of Spent Shot and Harmonization of the Approval Process

Barnett Rattner[1], Todd Sanders[2] and Gregory Fleming[2] (1)U.S. Geological Survey, Eastern Ecological Science Center, (2)U.S. Fish and Wildlife Service, Division of Migratory Bird Management

In the mid-twentieth century, the annual loss of tens of thousands of waterfowl to lead poisoning associated with ingestion of spent shot resulted in a formal U.S. Fish and Wildlife Service (USFWS) review and Environmental Impact Statement that proposed use of nontoxic steel shot for waterfowl hunting. Due to secondary lead poisoning of scavenging bald eagles (Haliaeetus leucocephalus), in 1986 the USFWS subsequently implemented a five-year phased process requiring the use of non-lead ammunition for hunting waterfowl. Ecotoxicological testing and approval guidelines of substitutes for lead shot were developed to evaluate safety of candidate materials from a broad ecosystem perspective. To be approved, shot material must not cause significant toxicity (including death) in birds, other wildlife, or habitats; be identifiable as an approved nontoxic shot type using portable field-testing devices; and be formally approved through USFWS rulemaking. Using tiered testing guidelines and evaluation of each unique shot material, there are currently 14 shot types (e.g., combinations of various metals, alloys, polymers) approved for hunting waterfowl in the U.S. In contrast, in Canada any shot composed, by weight, of up to 100% iron, tungsten, tin, or bismuth, alone or in any combination of those substances; not more than 45% copper; not more than 40% nickel; not more than 7% Nylon 6, Nylon 11 or ethylene methacrylic acid copolymer, alone or any combination of those substances; and not more than 1% all other substances combined, are legal for use in waterfowl hunting. Notably, recent findings suggest that mobilized copper in some approved spent shot types could pose a hazard to aquatic invertebrates, and potentially even higher vertebrates. Potential options for 21st century assessment of the environmental hazard and risk of spent shot, as well as harmonization of the evaluation and approval process,

will be discussed.

3.08.P-Th039 Maternal Transfer of Organic Pollutants in a Stranded Mother-Fetus Pair of Threatened Bigg's Killer Whales From Canada's West Coast

Kiah Lee[1], Stephen Raverty[2], Paul Cottrell[3] and Juan José Alava[4] (1)Ecological Change and Environmental Stressors Lab, Department of Natural Resources, McGill University, Montreal, Quebec, Canada, (2)Animal Health Centre, BC Ministry of Agriculture, Food and Fisheries, Abbotsford, BC, Canada., (3)Fisheries and Oceans Canada (DFO), Fisheries and Aquaculture Management, Vancouver, BC, Canada, (4)School of Resource and Environmental Management, Simon Fraser University, Burnaby, BC, Canada

Maternal transfer of organic contaminants is a toxicokinetics process observed in marine mammal species. The maternal transfer ratio/rate (MTR) of pollutants in Bigg's killer whales (BKW) from Pacific Canada is unknown. We contribute to the first MTR assessment, including persistent organic pollutants, alkylphenols (APs), and polycyclic aromatic hydrocarbons (PAHs), in blubber, muscle, kidney and liver tissues of a stranded BKW-mother-fetus pair found on Vancouver Island. The dominant blubber concentrations in the BKW-mother-fetus were polybrominated diphenyl ethers(∑PBDE:mother=1720 mg/kg-lw:fetus=646 mg/kg-lw)>polychlorinated biphenyls(∑PCB:mother=23.7 mg/kg-lw:fetus=6.50 mg/kg-lw)>organochlorine pesticides(∑OCPs:mother=22.8 mg/kg-lw:fetus=10.8 mg/kg-lw), followed by ∑PAHs(mother=1.08 mg/kg-lw:fetus=0.484 mg/kg-lw) and α-HCBDD(mother=0.219 mg/kg-lw:fetus=0.056 mg/kg-lw). Liver concentrations were dominated by ∑PAH(mother=7.183 mg/kg-lw:fetus=4.03 mg/kg-lw), followed by per- and polyfluoroalkyl substances(∑PFAS: mother=0.148 mg/kg wet weight[ww]:fetus=0.09 mg/kg-ww), ∑APs(mother=0.05 mg/kg-lw:fetus=0.260 mg/kg-lw) and α-HBCDD(=0.047 mg/kg-lw:fetus=0.026 mg/kg-lw), while muscle concentrations were: ∑PAH(mother=1.755 mg/kg-lw:fetus=3.624 mg/kg-lw), ∑APs(mother=0.129 mg/kg-lw:fetus=0.166 mg/kg-lw), α-HBCDD(=0.085 mg/kg-lw: fetus=0.043 mg/kg-lw), and ∑PFAS(mother=0.036 mg/kg-ww:fetus=0.024 mg/kg-ww). Depending on the tissues assessed (muscle, liver, kidney), the MTR revealed that overall two APs (4-NP,NP2EO), several PFASs (e.g., PFUnA>PFTrDA>PFDA>PFNA>PFOS>PFTeDA>PFDoA>PFDS>PFHxS>PFOSA) and PAHs (e.g.,2-Methylphenanthrene, 2-Methylnaphthalene, Fluoranthene, C4-Phenanthrenes/Anthracenes, Naphthalene, C1-Naphthalenes) were readily transferred to the fetus (MTR>1). For blubber, some PAH compounds (e.g.,4,6-Dimethyldibenzothiophene>2-Methylfluorene>1,7-Dimethylphenanthrene>C1-Fluorenes>1-Methylphenanthrene>C2-Fluorenes>C4-Naphthalenes), specific congeners for PCBs and PBDEs, plus 3 OCPs (Endrin Ketone>Endosulfan Sulphate>Hexachlorobenzene) underwent maternal transfer(MTR>1). Contaminant exposure, feeding preferences, and contaminant metabolism, along with the prior offloading of contaminants to the first fetus/calf, influence maternal contaminant transfer. This study further improves our understanding of transplacental transfer and health risks, providing new information to inform risk management of toxic pollutants to support the conservation of this species.

Disclaimer/Disclosure: Funding was provided by Fisheries and Oceans Canada (DFO)

3.08.P-Th040 One Health Sentinels: Systems Approach Using Microbiome and Microplastic Profiling in Florida Manatees To Evaluate Coastal Ecosystem Stress and Advance Health Resilience

Emily Kintzele[1], Baylie Reisch[1], Maite De Maria[2], Angelica Ahrens[3], Bridget Baker[4], Margaret Hunter[5] and Tracie Baker[1] (1)University of Florida, Department of Environmental and Global Health, (2)Cherokee Nation System Solutions in support of U.S Geological Survey, Wetland and Aquatic Research Center, (3)University of Florida, Department of Microbiology and Cell Science, (4)University of Florida, Department of Wildlife Ecology and Conservation, (5)U.S Geological Survey, Wetland and Aquatic Research Center

Microplastics are ubiquitous pollutants found throughout aquatic environments, including the air, sediment, water, plants, and animals, raising concern for vulnerable species such as the Florida manatee. When introduced to the body, microplastics can cause mechanical damage to the digestive tract through abrasions or perforations of the gut mucosal lining, the first line of defense against pathogens and bacterial translocation. Microplastics may also alter feeding behavior or nutrient availability, potentially disrupting the gut microbiome by depriving microbial symbionts of essential substrates.

This study introduces an innovative, noninvasive approach to investigate both microplastic exposure and microbiome shifts in manatees through fecal analysis. In collaboration with the United States Geological Survey, fresh and archived fecal samples were collected from manatee health assessments conducted in Brevard County, Crystal River, and the Everglades from 2011-2025. Paired environmental water and sediment samples were also collected from the three locations to evaluate potential exposure pathways.

Initial analyses identified microplastics in manatee fecal samples dating back to 2011, with significant differences observed among locations. FTIR analysis conclusively showed that polyethylene and polypropylene were the most common polymer types among all matrices. 16S rRNA sequencing analysis demonstrates abundant microbial communities with significant differences in microbial composition across time, sex, and geographic location. Pairwise comparisons were used to evaluate temporal, spatial, and sex-based variation while also considering unusual mortality events (UMEs) and associations with dietary, anthropogenic, or environmental stressors.

By integrating microbiome science with emerging contaminant profiling in manatees, this One Health focused project highlights how anthropogenic ecosystem disturbance may impact coastal and wildlife health. These findings establish a foundation for understanding pollutant exposure pathways in aquatic systems and support the role of manatees as sentinel species for environmental monitoring, conservation, and contamination mitigation strategies.

3.08.P-Th041 Assessing Polycyclic Aromatic Hydrocarbon (PAH) Levels and Temporal Trends in the Endangered St. Lawrence Beluga Whale

Gabriel Gellert[1], Lisa Loseto[2], Marie Noel[3], Veronique Lesage[3], Stephane Lair[4] and Tanya Brown[1] (1)Simon Fraser University, (2)Fisheries and Oceans Canada, Simon Fraser University, (3)Fisheries and Oceans Canada, (4)Universite de Montreal

Polycyclic aromatic hydrocarbons (PAHs) are persistent environmental contaminants with well-documented carcinogenic and toxic effects in wildlife. The St. Lawrence Estuary (SLE) is an industrial and urban corridor,

that supports a small, isolated population of ~1850 beluga whales (Delphinapterus leucas). SLE belugas are classified as Endangered and have historically exhibited a high incidence of cancer, which has been associated with chronic exposure to PAHs, which were released by aluminum smelters in this region between 1926 and 1976. Gastrointestinal cancers have declined considerably over the past two decades; however, SLE belugas have shown no clear signs of recovery. High priority recovery measures for this population include identifying contaminant sources within the SLE, and quantifying priority contaminants in beluga tissue. Recent advances in analytical chemistry enable the detection of a wider array of PAH analytes than ever before, offering new insight into the behaviour of these compounds in marine mammals. Here, we evaluate (1) PAH concentrations and profiles in blubber sampled from stranded adult SLE belugas and (2) assess trends in PAH content over a 27-year period (1997-2024). We also explored the potential influences of age, sex, body size, and feeding ecology (through stable isotopes analysis). Blubber samples (n = 26; 9 female, 17 male) were analyzed for 76 PAH analytes (20 parent, 56 alkyl) using gas chromatography/mass spectrometry (SGS AXYS Analytical Services Ltd., procedure MLA-021, Rev. 12, Ver. 07). Alkyl, petroleum-derived PAHs dominated across sampling years. Total PAHs declined substantially between 1997-2024, decreasing by approximately 12% annually. Insights gained from this first study of PAH concentrations and temporal trends in SLE beluga whales will inform conservation efforts and improve our understanding of factors that may be impeding this population's recovery.

Disclaimer/Disclosure: Funding disclosure: this research was funded by Fisheries and Oceans Canada and Simon Fraser University.

3.08.P-Th042 Multi-Decadal Trends of Ultraviolet Absorbents and Industrial Antioxidants in Aquatic Bird Eggs From the St. Lawrence (1972–2024)

Christina Petalas[1], Jennifer Provencher[2], Zhe Lu[3], Shane de Solla[4], Margaret Eng[2], Kyle Elliott[1] and Raphael Lavoie[5] (1)McGill University, (2)Environment and Climate Change Canada (ECCC), (3)University of Quebec at Rimouski (UQAR), (4)McMaster University, (5)Environment Climate Change Canada (ECCC)

Despite regulatory progress on legacy persistent organic pollutants, plastic-associated chemicals continue to enter and persist in aquatic environments with limited long-term constraint. Ultraviolet (UV) absorbents and industrial antioxidants are increasingly detected globally, yet their historical occurrence and trophic exposure remain largely unresolved, particularly in sensitive coastal systems such as the St. Lawrence system. We quantify 16 plastic-related additives in archived seabird eggs spanning 1972–2024 across multiple colonies throughout the St. Lawrence system. The dataset includes four species representing distinct foraging ecologies: double-crested cormorant (Nannopterum auritum), northern gannet (Morus bassanus), herring gull (Larus argentatus), and great blue heron (Ardea herodias), sampled from five breeding locations. This study aims to (1) evaluate long-term temporal trends in these emerging contaminants, (2) compare contaminant profiles across species and regions, and (3) establish historical baselines in North Atlantic coastal wildlife. Analyses revealed substantial variability in contaminant occurrence across compounds and species, with gulls having the highest levels. UV328 and UV326 were the most frequently detected additives, occurring in 90.7% and 75.5% of samples, respectively. Temporal variability was observed across the 52-year archive, further suggesting changing inputs of plastic additives into the St. Lawrence food web over time. These findings provide critical insight into the long-term persistence and ecological exposure of emerging plastic-related contaminants in wildlife populations.

3.08.P-Th043 Evaluation of Sensitivity to Anticoagulant Rodenticides in Two Avian Species Related to Endangered Endemic Species From the Bonin Islands

MASASHI KOIDE[1], Kohei OGASAWARA[1], Yoshiya ODAYA[2], Yared Yohannes[1], Yoshinori IKENAKA[1], Mayumi Ishizuka[1] and Shouta Nakayama[1] (1)Hokkaido University, (2)Natural History Museum and Institute

Background: The Bonin Islands have a unique ecosystem that supports many endemic and endangered species, including the Bonin Greenfinch (Chloris kittlitzi) and the Red-headed Wood Pigeon (Columba janthina nitens). Population declines of these species have been attributed to ecosystem disturbance caused by invasive rodents. To mitigate these impacts, anticoagulant rodenticides (ARs) have been used for rodent eradication. ARs, which inhibit blood coagulation, are classified into first- (FGARs) and second-generation (SGARs). Although ARs are widely used worldwide, secondary poisoning on non-target wildlife have been reported, particularly for SGARs. In the Bonin Islands, one of the FGAR, Diphacinone, is currently being deployed, and the additional use of SGARs is under consideration. However, their potential impacts on endemic species remain poorly understood, highlighting the need of evaluating AR sensitivity.
Methods: In vivo AR exposure studies were conducted using the Oriental Greenfinch (Chloris sinica) and the Rock Pigeon (Columba livia), which are closely related to the endemic birds. In the Greenfinch study, birds were orally administered Diphacinone (4.0 mg/kg; N=4). Blood samples were collected at multiple time points up to 168 hours after exposure, and clotting time and plasma AR concentrations were measured. The Pigeon experiments were conducted using the same dose and analytical methods as those employed in the previous test. In this experiment, groups for Brodifacoum and Difenacoum, both of which are SGARs, were established as well as the group for Diphacinone (N=5 for each).
Results and Discussion: In the Greenfinch study, no significant prolongation of clotting time, a clinical sign of AR exposure, was observed after exposure. Plasma analyses revealed a rapid increase in metabolite concentrations (Max: 2.30±0.44 μg/mL), accompanied by a marked decline in Diphacinone concentrations within 12 hours post-exposure, suggesting a high metabolic capacity for AR. These findings indicate that the Greenfinch may have relatively low sensitivity to Diphacinone. In contrast, the Pigeon study showed a marked prolongation of clotting time, with the greatest increase occurring in the Difenacoum group, where values exceeded three times the baseline level at 72 hours post-administration (30.8±9.2s). These results emphasize the importance of conducting species- and compound-specific sensitivity assessments of non-target wildlife prior to AR application.

3.08.P-Th044 Viticultural Landscape Use Drives Pesticide Exposure and Impairs Body Condition in a Free-Ranging Songbird

Pauline Bellot[1], François BRISCHOUX[1], Clémentine FRITSCH[2], Hélène BUDZINSKI[3], Alexis CHAZEAUBENY[3], Cécile RIBOUT[1], Patrick PARDON[3] and Frédéric ANGELIER[1] (1)Centre d'Études Biologiques de Chizé (CEBC), CNRS, Villiers-en-Bois, France., (2)Laboratoire Chrono-environnement, CNRS, Université de Bourgogne Franche-Comté, Besançon, France., (3)Environnements et Paléoenvironnements Océaniques et Continentaux (EPOC), CNRS, Université de Bordeaux, Bordeaux, France.

Agricultural intensification exposes wildlife to increasingly complex pesticide mixtures, yet their sublethal effects on non-target species remain poorly characterized. The impact of viticulture on wild birds is particularly understudied compared to arable systems, despite vineyards accounting for a disproportionate share of pesticide use, fungicides alone representing up to 80% of substances applied in French vineyards. We investigated how

viticultural landscape use shapes pesticide exposure and associated health effects in house sparrows (Passer domesticus) across cereal and viticultural agroecosystems. Juvenile feathers were collected at six sites and analyzed using two complementary approaches: targeted screening of triazole fungicides and a broad multi-residue panel covering multiple pesticide families. Agricultural landscape composition was characterized around each site to build a continuous viticultural activity gradient, complementing the categorical habitat comparison. Morphological (tarsus length) and body condition metrics were then related to individual contamination levels and landscape variables. Triazole fungicides were ubiquitous across all sites, with 15 of 21 targeted molecules detected in feathers, including 10 no longer approved for use. Sparrows from viticultural areas showed significantly higher contamination: triazole detections were more than twice as frequent as in cereal areas, and concentrations increased with the viticultural gradient. Across the full multi-residue screening, fungicides dominated contamination profiles, followed by herbicides and insecticides, with a clear viticultural signature, 16 molecules detected exclusively in vineyard habitats versus one in cereal fields. Importantly, the viticultural landscape gradient was associated with reduced tarsus length in juveniles, while body mass and condition were negatively influenced by total pesticide load in interaction with this gradient, with several fungicides emerging as key contributors. Together, these findings demonstrate that viticultural agroecosystems represent a chemically constrained environment for birds with measurable consequences for development and body condition and establish the house sparrow as a relevant bioindicator of pesticide pressure in vineyard landscapes.

3.08.P-Th045 The Integrated Chemical Mixtures Project - Targeted & Non-Targeted Screening in Canadian Sentinel Bird Species for per- and Polyfluoroalkyl Substances

Tristan Smythe[1], Shane de Solla[2], Kim J. Fernie[3], Emily Choy[4] and Robert Letcher[3] (1)., (2)McMaster University, (3)Environment and Climate Change Canada (ECCC), (4)McGill University

Modern advances in non-targeted analysis (NTA) methods permit their application in complex environmental matrices including biological tissues. While individual groups of legacy and known contaminants are the focus of existing regulatory frameworks, there is a dearth of information in wildlife for unmeasured or unmonitored substances (e.g., transformation products [TPs], alternative or replacement chemicals). Per- and polyfluoroalkyl substances (PFAS) have seen increasing regulation leading to the advent of alternative PFAS that remain poorly characterized. PFAS exposure of wildlife to many precursors (e.g., fluorotelomers) and TPs (e.g., metabolites) is not well understood. The objective of this study was to compare PFAS profiles using targeted and non-targeted screening (NTS) methods in sentinel bird species, the European starling (Sturnus vulgaris), tree swallow (Tachycineta bicolor), and American herring gull (Larus smithsonianus), at urban and non-urban sites across Canada. Eggs were collected in 2024 and 2025 from study sites across Southwestern Ontario. Egg ∑PFAS concentrations via targeted analysis were greatest at the Brantford landfill site in starlings (median: ~1000 ng/g ww) compared to tree swallows (median: ~400 ng/g ww). ∑PFAS concentrations at Hamilton sites were greatest in herring gulls (~ 500 ng/g ww) followed by starlings and tree swallows (< 50 ng/g ww). Emerging PFAS such as GenX, F-53B, ADONA, and two targeted side-chain fluorinated polymer surfactants were undetectable. Multiple fluorotelomer alcohol (FTOH) TPs were identified during NTS, including 6:2, 8:2, 10:2, and 12:2 FTOH-sulfates in eggs from the Brantford landfill site but only 8:2 FTOH sulfates was detected in eggs from all non-reference sites. FTOH-sulfates are presumably biomarkers of FTOH exposure, although precursor FTOHs were not detectable in any sample. Relative levels of branched perfluoroalkyl acid isomers at each site will be described, as well as the low levels of fluorotelomer carboxylic acid (FTCA) precursors and

polyfluoroalkyl phosphate esters (PAPs) in Brantford bird eggs. This work is foundational for the future of wildlife biomonitoring as methods move from traditional triple quadrupole instrumentation to highly sensitive and selective high resolution MS instruments. However, other comprehensive sample preparation techniques are required for the characterization of wildlife tissue samples for multiple classes of compounds.

Disclaimer/Disclosure: This work was supported by Environment and Climate Change Canada's Integrated Chemical Mixtures Project (ICMP) and Chemicals Management Plan (CMP).

3.08.P-Th046 Emergence and Rapid Increase of Very-Long-Chain Chlorinated Paraffins in Peregrine Falcon Eggs Across the Laurentian Lower Great Lakes-St Lawrence River Basin

Bo Yuan[1] and Kim Fernie[2] (1)Norwegian University of Science and Technology (NTNU), (2)Environment and Climate Change Canada (ECCC)

Since the Stockholm Convention listed short-chain and medium-chain chlorinated paraffins (CPs) as persistent organic pollutants, long-chain CPs have received increasing production and regulatory attention as potential replacements. This category comprises nearly 600 homologues and includes two subcategories: conventional long-chain CPs (LCCPs, C18-20) and very-long-chain CPs (vLCCPs, C>20). However, long-term temporal trends of vLCCPs in wildlife remain poorly understood, as vLCCPs have rarely been quantified separately from conventional LCCPs. By incorporating vLCCP standards into the analytical method, we separately quantified vLCCPs and conventional LCCPs in eggs of peregrine falcons (Falco peregrinus) collected between 1995 and 2024 across southern Ontario and southwestern Quebec, Canada. Concentrations of vLCCPs exhibited a striking power-law increase over time, reaching nearly 20,000 ng/g lipid weight in 2024, approximately doubling the highest wildlife concentrations previously reported globally. Total CP concentrations in eggs also showed a decline during 2016-2020 followed by a strong post-2020 rebound driven primarily by vLCCPs, consistent with temporal patterns observed in plasma of nestling peregrine falcons. In contrast, egg levels of medium-chain CPs (MCCPs) remained relatively stable across years. Concentrations of conventional LCCPs (C18-20) were strongly correlated with those of MCCPs, suggesting substantial contributions from MCCP-related impurities or co-use patterns. No clear temporal trends were observed in eggs collected from the Montreal region, where CP concentrations and homologue fingerprints were remarkably similar to those from the Greater Toronto region despite their different local emission characteristics. These findings provide one of the first long-term wildlife records demonstrating the rapid emergence of vLCCPs in apex predators and suggest a major recent shift in CP usage and environmental exposure patterns in North America, and highlight the need to better understand potential endocrine and biological implications associated with increasing exposure in wildlife.

3.08.P-Th047 Addressing Widely Recognized Issues in Avian Toxicity Testing: A SETAC Focused Topic Meeting

Tom Bean[1] and Beatrice Hernout[2] (1)BASF Agricultural Solutions US LLC, (2)Exponent

Avian toxicity testing is a requirement of environmental risk assessment for plant protection products and many industrial chemicals, yet guideline studies use large numbers of animals and have generally changed little in decades. Opportunities to reduce vertebrate use while reducing uncertainty are increasingly promoted by

advances in new technologies and alternative approaches which have emerged since current guidelines were developed.

The SETAC Wildlife Toxicology Interest Group is proposing a Focus Topic Meeting (FTM) for 2027 to evaluate the state of the science and identify opportunities to modernize avian toxicity testing and risk assessment. The FTM will convene stakeholders from governmental, academic, business, and non-governmental organizations to critically assess current in vivo approaches and explore integration with emerging methodologies. Key themes include refinement of reproduction and dietary studies, reconsideration of species selection, improving ecological relevance, evaluating the necessity of existing tests, and identifying animal alternatives to test non-toxic chemicals. The FTM will highlight advances in new approach methodologies (NAMs), including omics technologies, bioaccumulation assays, embryo-based methods, and biomarkers, alongside computational tools such as interspecies correlation models, physiologically based kinetic models, population models, and bioinformatics approaches. These tools offer the potential to reduce uncertainty, enable cross-species extrapolation, and support more mechanistic, data-rich assessments when incorporated into testing frameworks. Statistical innovations, including benchmark dose approaches and the use of historical control data, will also be evaluated for their role in improving study design and interpretation.

The overall goal is to define a path toward an integrated, tiered framework for avian risk assessment that achieves “more with less”: generating higher-quality and/or more ecologically relevant data than the current required test data while reducing animal use in alignment with the 3Rs principles (Replacement, Reduction, Refinement). Meeting outcomes will include a synthesis of current knowledge and prioritized recommendations to support efforts to advance testing strategies. A longer-term objective, supported by a follow-up workshop in 2028 or 2029, is to develop updates and new test guidelines which can be incorporated into regulatory frameworks.

3.08.P-Th049 First Year of a Long-Term Microplastics Monitoring Program at the Bodega Marine Reserve

Cristina Torres Duarte[1], Zeke Spooner[1] and Christina Pasparakis[1] (1)University of California Davis

Microplastics (MPs) are emerging contaminants that pose a growing threat to aquatic wildlife through environmental exposure and trophic transfer. MPs can adhere to the surfaces of primary producers, be ingested by herbivores, and subsequently be transferred to higher trophic levels, creating multiple pathways for exposure throughout marine food webs. Understanding the distribution and movement of MPs across ecological compartments is critical for evaluating potential risks to wildlife populations.
To assess MP exposure within a relatively low-impact coastal ecosystem, the Toxicology, Physiology, Ecology, and Conservation (ToPEC) Laboratory established a long-term monitoring program at the Bodega Marine Reserve (BMR), a marine protected area on the northern California coast. Seasonal sampling is conducted at two geographically distinct sites within the reserve—one wave-exposed and one sheltered—to evaluate how environmental conditions influence MP distribution and trophic transfer. MPs are quantified in seawater, primary producers (macroalgae), the grazing snail Tegula funebralis, and the filter-feeding mussel Mytilus californianus, providing insight into contaminant movement across multiple trophic levels.
Preliminary results from Spring and Summer sampling indicate no significant differences in particle concentrations between sites; however, particle abundance was consistently higher across environmental

matrices during Spring. Among primary producers, the smooth-surfaced alga Mazzaella sp. contained higher particle concentrations (25.7 particles g^{-1} dry tissue) than the rough-surfaced Mastocarpus sp. (16.8 particles g^{-1} dry tissue), suggesting that species-specific surface characteristics may influence particle retention and subsequent exposure to grazers. These findings highlight potential mechanisms governing MP availability to marine consumers and underscore the importance of biological and environmental factors in determining contaminant transfer through coastal food webs.
Season pattern for the first year of data will be presented, focusing on particle distribution and trophic transfer to improve our understanding of wildlife exposure to microplastics within marine protected ecosystems.

3.08.P-Th050 Building a Toxicokinetic Model for Microplastic Uptake, Translocation, and Depuration in Fathead Minnow (Pimephales promelas)

Meredith J. Omer[1], Chelsea M. Rochman[1], Maura McGregor[1], Jose Ponce De Leon Garcia[1] and Kaede Sorensen[1] (1)University of Toronto

Microplastic is a global pollutant of increasing governmental and public concern. Research has clearly demonstrated that microplastics are present not just in the environment but also in animal and human tissues. However, the mechanisms and rates by which these particles transport within and between organs and their residency times, are not yet understood. To address these knowledge gaps, we conducted an experiment to determine the rates of microplastic uptake, translocation, and depuration in laboratory raised fathead minnow (Pimephales promelas). Fish were exposed through their diet using a mix of four plastic polymers in a range of sizes and shapes (fragments ranging in size from 15-1400 µm and fibers ranging in size from 6 - 4723 µm). The study consisted of a four-week uptake period followed by a four-week depuration period, over which fish were regularly sampled. The liver, muscle, and gastrointestinal tracts were dissected and separately chemically digested in 10% KOH to isolate microplastics. The isolated particles were counted, identified, characterized, and measured. The concentrations of microplastic within the tissues at the various sampling time points will be used to construct a toxicokinetic model of the movement of microplastic within fish tissues. The rate at which microplastics are moved through tissues are relevant to microplastic's biological fate and bioaccumulation potential. This work advances our understanding of these critical concepts and was undertaken to broaden our knowledge of how organisms internally interact with and process microplastics. Findings to date will be presented here.

3.08.P-Th051 Microplastic Accumulation in Quillback Rockfish Inside and Outside a Marine Reserve

Jordan Colby[1], Dylan Lin[2], Aisyah Suripto[2], Cristina Torres Duarte[1], Jenessa Gjeltema[1] and Christina Pasparakis[1] (1)University of California Davis (UC Davis), (2)UC Davis

Microplastics (MPs), plastic particles smaller than 5 mm, have infiltrated nearly every corner of the ocean, from highly urbanized estuaries to some of the world's most remote ecosystems. While their environmental presence is well documented, much less is known about how MPs accumulate in marine organisms under natural conditions and whether conservation strategies influence exposure. Marine protected areas (MPAs) are widely recognized for conserving biodiversity and sustaining fisheries, yet whether they provide co-benefits by reducing contaminant exposure remains poorly understood.
Rockfish (Sebastes spp.) are valuable model species for investigating the bioaccumulation and biomagnification

potential of MPs in marine ecosystems. Their exceptional longevity, with some species living up to 200 years, provides opportunities to examine MP accumulation across decades of exposure. As predatory fishes, they offer insight into trophic transfer through coastal food webs, while their strong site fidelity and relatively small home ranges make them useful indicators of local contamination patterns.
To test whether protection status influences MP accumulation, we leveraged a rare sampling opportunity provided by a NOAA Fisheries stock assessment survey that included collections from both inside and outside the Southeast Farallon Island State Marine Reserve. We quantified and characterized MPs in the gastrointestinal tract, liver, and edible muscle tissue of quillback rockfish (Sebastes maliger) to evaluate tissue-specific accumulation, translocation, bioaccumulation potential, and differences between protected and reference sites. Otolith-derived age estimates were used to evaluate the bioaccumulation potential of MPs over time. MPs were detected in 100% of individuals and across all tissue types, demonstrating widespread exposure and particle translocation into tissues relevant to seafood consumption. Fibers were the dominant particle type across tissues and locations. Preliminary data suggests fish collected within the marine reserve contained significantly fewer MPs than those collected from reference sites. To our knowledge, this is the first study to directly compare MP burdens in fish collected from inside and outside a fully protected marine reserve. These findings highlight the potential for protection status to influence contaminant accumulation and expand the scope of MPA performance beyond traditional biodiversity and fisheries metrics.

3.08.P-Th052 Integrating Physiology and Contaminant Monitoring To Develop Shark-Specific PBTK Models for Mercury and PFAS

Paige Powell Paige Powell[1], Gregory Aniolek[1], Melissa Walker[1], Romina Dotson[1], Bryan Frazier[2], Ashley Galloway[3], Claire Benson[2] and Kylie Rock[1] (1)Clemson University, (2)South Carolina Department of Natural Resources, (3)South Carolina Department of Natural Resource

Sharks are essential for maintaining marine ecosystem balance, yet their long lifespans, high trophic status, and slow reproduction increase susceptibility to toxicological stressors. Mercury (Hg) and per- and polyfluoroalkyl substances (PFAS) are two globally distributed contaminants that bioaccumulate in marine food webs and have been shown to disrupt neurologic, hepatic, and reproductive processes in vertebrates. However, the internal distribution and physiological processing of these contaminants remain poorly characterized due to ethical and logistical limits on lethal sampling. We hypothesize that contaminant concentrations in non-lethal blood and muscle samples can reliably predict burdens in internal organs (e.g., liver, brain, gonads). By integrating empirical contaminant data, trophic ecology, and shark-specific physiological parameters, we can address this gap by mechanistically describing contaminant transport and accumulation across tissues using physiologically based toxicokinetic (PBTK) modeling.
Blood and muscle were collected non-lethally from finetooth and blacktip sharks in South Carolina, in collaboration with the South Carolina Department of Natural Resources (SCDNR). Opportunistic organ samples from incidental mortalities were collected to aid model calibration. Hg concentrations were quantified by thermal decomposition–amalgamation atomic absorption spectrophotometry (EPA Method 7473), and PFAS congeners are being analyzed via high-performance liquid chromatography tandem mass spectrometry. Preliminary finetooth data has shown a strong correlation between Hg concentration in muscle and kidneys, brain, and gonads (R2= 0.96, 0.97, 0.99, respectively), suggesting that muscle may serve as a good proxy for estimating Hg concentrations in these organs. Ongoing work is quantifying circulatory dynamics through Doppler-based measurements of cardiac output and regional blood flow, which, together with tissue:blood

partition coefficients, organ volumes, metabolic rates, and clearance parameters will be integrated into Bayesian calibrated PBTK models developed in R and Berkeley Madonna. The developing model will allow prediction of organ-specific Hg and PFAS burdens, enhancing conservation for species where lethal sampling is not possible. In partnership with SCDNR and NOAA, this work will advance evidence-based risk assessment, support proactive conservation strategies, and strengthen coastal ecosystem-based management of apex predators.

Disclaimer/Disclosure: Womens Divers Hall of Fame Oceans and Human Health Scholarship

3.08.P-Th053 Linking Corixid Migration to Contaminant Movement Between Prairie Pothole Wetlands and River Food Webs

Jillian Papke[1], Markus Brinkmann[1], Christy Morrissey[1], Sonia Cabezas[1] and Tim Jardine[1] (1)University of Saskatchewan

Millions of corixids (family Corixidae), more commonly known as water boatmen, develop in wetlands of the Prairie Pothole Region (PPR) and migrate in mass numbers to river systems in the fall to overwinter. This migration is necessary for corixid survival as most wetlands in the PPR freeze solid during the winter. The PPR receives inputs from agricultural runoff and has low drainage, which leads to the buildup of environmental contaminants, especially pesticides, in wetlands. Because corixids spend their developmental period in these wetlands, they may accumulate pesticides and other contaminants before migrating to river systems, creating a potential pathway for contaminants to be transferred from agricultural landscapes into riverine food webs. We are addressing this challenge by determining pesticide residues in the tissues of corixids and other wetland invertebrates in the PPR. Invertebrate samples, including corixids, were collected in the late summer from nine wetlands that cover a range of site conditions from native grasslands to croplands. Corixids were then sampled from the North and South Saskatchewan rivers after migration in the fall. Using gas chromatography-mass spectrometry and liquid chromatography-mass spectrometry, samples are analyzed for pesticides that are persistent in the environment, have the potential to bioaccumulate, and are currently used in Canada, including neonicotinoids and pyrethroids. We hypothesize that pesticide detection rates will be similar among the different wetland site types as pesticides are ubiquitous in water in the region, and that corixids will have higher concentrations than other co-occurring invertebrates because of their high lipid content. Overall, because of their high biomass in the region, we anticipate that corixids transport significant masses of contaminants even if concentrations are low, allowing pesticides to enter riverine food webs prior to the winter. This study is relevant to understanding how corixids and other migratory insects can act as a transport vector linking contaminants from wetlands to rivers in dryland regions.

4. Chemistry and Exposure Assessment

Advancing Non-Targeted Analysis: Integrating Analytical Rigour, Informatics Innovation and Risk Assessment for Exposure Characterization

4.01.T-01 Bridging Targeted and Non-Target Screening: A Multi-Class LC-HRMS Framework for Emerging Contaminants in Environmental Waters

Karine Belzile[1], Francesca Benoit[1], Sébastien Côté[1], Caroline Demers[1], Martin Duchesneau[1], Marie-Claire Grenon[1], Karine Lessard[1], Gabriel Munoz[1], Véronique Perreault[1] and Sabrina Simard[1] (1)CEAEQ, MELCCFP

Suspect screening and non targeted analysis based on liquid chromatography high resolution mass spectrometry (LC-HRMS) are increasingly popular for characterizing complex contaminant mixtures. However, routine implementation remains challenging due to numerous analytical pitfalls, including time-dependent stability issues, unsuited extraction strategies, data processing complexity and the lack of harmonized validation practices. Here, we synthesize the findings from a collaborative project aimed at developing a multi-class LC-HRMS screening framework for environmental waters. The optimization approach was grounded in an initial set of over 250 contaminants of environmental relevance spanning multiple contaminant classes (e.g., pharmaceuticals and personal care products, current-use pesticides, PFAS, and other industrial and urban chemicals). This known-to-unknown strategy provided a basis to assess analytical performance across a broad chemical space, enabling expansion toward suspect screening. Sample preparation and data acquisition parameters were selected using a multi-criteria desirability approach to simultaneously optimize recovery and sensitivity. Attention was also paid to blank contamination, matrix effects, and other analytical artifacts. Instead of a "one-size-fits-all approach", the designed method is adjustable as a function of expected contamination context, ranging from dilute-and-shoot to large-volume automated solid-phase extraction. The method was applied to screen these target and other suspect-target contaminants and transformation products in natural waters and wastewaters, using database annotation. The project was structured as a team based initiative involving analysts and technicians, facilitating knowledge transfer and harmonization of QA/QC practices. This collaborative framework also enables feedback loops to expand current official methods, providing a practical bridge between targeted and non-targeted analysis.

4.01.T-02 A Workflow for Harmonization of Non-Targeted Analysis Data in Support of Downstream Analytics

Troy Ferland[1], Anna Boatman[2], Mark Wilson[2] and Heather Whitehead[1] (1)Chemical Insights Research Institute a unit of UL Research Institues, (2)UL Research Institutes

Non-targeted analysis (NTA) is rapidly expanding its footprint amongst academic, governmental, and other regulatory laboratories attempting to characterize chemical space in media of interest (e.g., drinking water, consumer products). NTA data reporting across disciplines remains varied despite guidance published by interested parties such as the "Best Practices for Non-Targeted Analysis" (BP4NTA) and NORMAN Network working groups. NTA is positioned to be the premier technique for comprehensive characterization of the chemical space of complex matrices, identifying emerging contaminants, and supporting research that drives regulatory decisions. However, gaps in both the reporting and aggregation of NTA data stand in the way of its

use in downstream applications. Here, we present a workflow for populating a database, “Chemical Insights' NTA” Database (CI-NTA), with NTA data 1) extracted from published studies, and 2) produced in-house. We developed a Python package to parse NTA data from a variety of common vendor outputs into harmonized, validated Pydantic models, from which we can harmonize chemical identifiers (e.g., CAS RN, SMILES, or chemical name) mapped to reported chemical features, fill any gaps in a feature’s chemical mapping, and perform feature quality control via simple Python method calls. Finally, data validated by the Pydantic models can be easily deposited into CI-NTA, Chemical Insights’ publicly available NTA database. CI-NTA is a powerful new resource that solves a key challenge with NTA data reporting by providing a means of validating reported chemicals into a harmonized format. This framework can be easily adapted by other NTA practitioners as a streamlined method for harmonizing and sharing NTA data following processing and publication.

4.01.T-03 A Platform-Independent Non-Targeted Approach for Investigating Suspected Pesticide Poisonings in Honey Bees

Audrey Dewar[1], Viviane Yargeau[2], Karl J. Jobst[3], Pierre Giovenazzo[4] and Pedro A. Segura[1] (1)Université de Sherbrooke, (2)McGill University, (3)Memorial University of Newfoundland, (4)Université Laval

The decline in bee health is a major concern resulting from multiple interacting stressors including parasites, pathogens, malnutrition, climate change and chemical contaminants. Among these factors, pesticides are of particular interest, as bees exhibit limited detoxification capacity, making them especially vulnerable. However, current targeted methods used to investigate suspected pesticide poisoning events often fail to establish a link between exposure and mortality, as measured concentrations may be insufficient to explain the observed toxic effects.

To address this challenge, this study developed a non-targeted suspect screening workflow for the detection of pesticides and their transformation products in honey bees. The proposed workflow combines two complementary and platform-independent strategies in parallel, an exact mass screening tool using the open-source software MZmine and a combinatorial analysis of tandem mass spectra (MS2) based on Similar Partition Screening, a cloud-based application. The method was designed with transferability and performance assessment in mind and enables the screening of more than 450 pesticides and transformation products in bees. Method performance was evaluated using well-defined metrics on three distinct liquid chromatography – high-resolution mass spectrometry platforms (LC-QqToF, LC-Q-Orbitrap and LC-cIMS-MS). Exact-mass-based screening demonstrated high sensitivity, with true positive rates ≥ 80% across the three instruments and consistent performance from 10 to 100 ng/bee. In parallel, MS2-based screening increased confidence in compound identification while maintaining low false positive rates.

Application of the method to bees exposed to atrazine enabled the detection of the parent compound, along with two transformation products, deethylatrazine and deisopropylatrazine, after 48 hours of exposure. These results demonstrate the ability of the workflow to identify relevant contaminants that may be overlooked using targeted approaches. This work provides a framework for investigating pesticide poisoning events when the parent compound alone cannot account for the observed toxic effects. More broadly, it contributes to the advancement of transferable suspect screening workflows and demonstrates the potential of the approach for analyzing chemical contaminants in complex biological and environmental matrices.

4.01.T-04 Nontargeted Spatial Feature Prioritization Applied to Passive Air Sampling: A

Story of Point Sources

Alexander Kasperkiewicz[1], Jenny Oh[1], Hayley Hung[2], Trevor VandenBoer[3], Alison McGregor[4], Jared Chisamore[5], Yushan Su[4], Hui Peng[1] and Frank Wania[1] (1)University of Toronto, (2)Environment and Climate Change Canada (ECCC), (3)York University, (4)Ministry of the Environment, Conservation and Parks, (5)Environment and Climate Change Canada

Nontargeted analysis (NTA) of environmental samples routinely generates tens of thousands of chemical features, making a strategy to prioritize and filter them an essential part of experimental design. We demonstrate a spatial prioritization approach that uses the geographic positions of a passive air sampling network to isolate point-source-derived contaminants near a petrochemical and plastics manufacturing hub in Sarnia, Ontario, Canada and a highway in Toronto, Ontario.

XAD-resin based passive air samplers (XAD-PAS) were deployed across 11 sites in Sarnia, 7 sites in Toronto, and 5 sites at a reference transect in Brantford, Ontario. Following deployment, extracts were analyzed by LC-HRMS (ESI +/-) and GC-HRMS (EI) to broaden the chemical screening effort. Spatial positions drove feature prioritization through two mechanisms: proximity-based decay with distance from suspected sources and chemical 'uniqueness' compared to reference sites. We used Brantford samples as a regional background and features common to both Sarnia and Brantford networks were subtracted to reveal Sarnia-specific signals. We observed significant feature list reductions using this approach, with only 90 chemical features remaining as Sarnia-specific in LC-ESI(-)-HRMS for example. Among these, dinoseb was confirmed using an authentic standard (confidence level 1) and shown to be highly localized around a single facility. Beyond identification, dinoseb served as a spatial tracer; correlation and clustering analyses across the network linked it to co-emitted features, including suspected propylparaben and N-nitrosalicylic acid. In Toronto, samples placed along a major highway allowed prioritization by proximity to traffic emissions, with the reference compound 2,4-dinitrophenol correlating with other nitrophenol-class species, as well as roadside-use pesticides, and degradation products of current-generation refrigerants (e.g. trifluoracetic acid). Our work shows how spatial feature prioritization can transform NTA datasets to allow XAD-PAS to help reveal point-sources for atmospheric contaminants.

4.01.T-05 How Many Toxicants Are We Exposed To?

Hui Peng[1] (1)University of Toronto

Humans are exposed to complex mixtures of xenobiotics. These chemicals can have detrimental effects on health depending on how they interact with ~20,000 human proteins. A fundamental question for environmental chemists is: which of these compounds are toxic and cause adverse health effects? Here, we propose a probabilistic model that addresses this question using large-scale chemical–protein interaction data generated through affinity-selection mass spectrometry (AS-MS). Across 3.54 million binary interactions from 407,271 compounds and 110 human proteins, we observe that the binding probability (PΘ) follows a log-log relationship with binding affinity (KD). By establishing a statistical model, we predict that toxicity in humans is dominated by a small number (<100) of potent chemicals under the Pareto law, rather than by the additive mixture effects of numerous weak compounds. This finding does not support the long-standing mixture effect hypothesis and instead highlights a 'sparse key driver' hypothesis.

Disclaimer/Disclosure: NSERC; IHI

4.01.T-06 Assessing Contact Lenses and Non-Targeted Mass Spectrometry as a Novel Approach for Characterizing Environmental Chemical Exposures Associated With Lifestyle

Anya Guo[1], Sara Vaezafshar[1], Annabel Zhang[2], Joseph Okeme[1] and Victoria Arrandale[3] (1)McMaster University, (2)Virginia Polytechnic Institute and State University, (3)University of Toronto

Risk factors for many diseases are driven by environmental factors, creating a need for accessible tools for characterizing environmental exposures and their biological responses. Currently, traditional matrices used for characterizing exposures are limited by being invasive to sample or not containing both endogenous and exogenous chemicals. Previous studies have demonstrated contact lenses as effective samplers for exposure markers in the tear fluid, addressing limitations in traditional matrices. However, no study has investigated relationships between the chemical profiles sampled by worn contact lenses and lifestyle factors. Here, we aim to 1) demonstrate the capability of contact lenses, combined with non-targeted mass spectrometry, as a method for measuring for exogenous and endogenous chemical exposures, 2) evaluate relationships between measured chemicals and lifestyle.

We recruited participants (n = 59) who self-sampled 3 pairs of worn contact lenses, and one blank unworn contact lens. Each participant also completed a survey including information on demographics, and behaviors potentially associated with chemical exposures. We extracted the contact lenses by vortexing in methanol and acetonitrile, then analyzed the extracts using liquid and gas chromatography coupled to non-targeted Orbitrap mass spectrometry. We processed the resulting raw data and annotated features using an in-house computational workflow.

We measured 1,387 features in worn contact lenses, including both endogenous (e.g., acyl carnitines, phosphocholines) and exogenous chemicals (e.g., from dietary and insecticide exposures). In association with lifestyle, 31 features had significantly different abundances in contact lenses worn by individuals who do and do not smoke cannabis. We also successfully measured known exposure markers for cannabis use (e.g., cannabidiol, Δ9-tetrahydrocannabinol). Further, 23 features were significantly more abundant in contact lenses worn by individuals who live in rural communities compared to those living in urban communities. Our results demonstrate contact lenses as a promising tool for measuring exposure markers, including chemical profiles demonstrating differences in lifestyle. As an accessible sampler, contact lenses can potentially be used in future, population-level studies for exposure assessment, facilitating regular monitoring for disease prevention.

Disclaimer/Disclosure: Funding is acknowledged from the Natural Sciences & Engineering Research Council of Canada and the Canada Foundation for Innovation

Advancing Non-Targeted Analysis: Integrating Analytical Rigour, Informatics Innovation and Risk Assessment for Exposure Characterization

4.01.P-Th156 A Census of Endocrine-Disrupting Chemicals Binding to Human Nuclear

Receptors

Xing Qian[1], Yufeng Gong[2] and Hui Peng[1] (1)University of Toronto, (2)Ocean University of China

Identification of endocrine-disrupting chemicals (EDCs) within complex mixtures remains a major bottleneck. We recently developed Protein Affinity Purification with Nontargeted Analysis (APNA) as a high-throughput approach for identifying bioactive chemicals at the exposome-wide level. Here, we expanded APNA to 48 human nuclear receptors by systematically identifying EDCs from three exposure-relevant matrices: human blood, household dust, and wastewater sludge.
Following affinity purification and ligand release, receptor-bound chemicals were analyzed by high-resolution LC–MS/MS. To date, the workflow has identified 658 receptor-enriched m/z–retention time features across 27 nuclear receptors compared with negative controls (fold change >5, $p < 0.05$). These features were further prioritized and annotated against extensive chemical databases. Among the receptor families examined, peroxisome proliferator-activated receptors produced the highest number of enriched features (PPARs, n = 161), with a notable preference for signals from sulfonate-containing chemicals. This study presents the first systematic mapping of EDCs across both exposome- and nuclear receptor-wide scales.

4.01.P-Th157 Introducing Non-Targeted Calibration for Understanding Passive Uptake Kinetics of Diverse Chemicals

Alyss McPherson[1], Celine Su[1], Ellie Davies[1], Anya Guo[1] and Joseph Okeme[1] (1)McMaster University

Passive air samplers (PASs) are a popular tool for large-scale monitoring of hazardous environmental compounds, but they are limited by a need for calibration. Conventional calibration methods calculate compound uptake rates from mass loading on the sampler through targeted analysis of pre-selected compounds using analytical standards, which are expensive and not always available. Most targeted calibration studies are therefore restricted to around 10-50 known compounds, often from the same chemical class. To overcome the limiting need for analytical standards and expand the scope of calibration studies, we developed a method for "nontargeted calibration" that substitutes mass loading with relative peak areas obtained from nontargeted analysis. We assessed this approach with an indoor calibration study of mesh-sheltered polydimethylsiloxane foam (PDMS-Mesh) and glass fibre filter (GFF-Mesh) PASs co-deployed alongside AASs. We then analyzed the samples with nontargeted liquid chromatography coupled to quadrupole time-of-flight mass spectrometry to obtain peak areas for plotting uptake curves. We derived generic uptake rates of 1.16 ± 0.34 m3 day−1 dm−2 for PDMS-Mesh from 67 features and 0.50 ± 0.33 m3 day−1 dm−2 for GFF-Mesh from 48 features, consistent with uptake rates reported by targeted calibration studies for various indoor PAS designs. Uptake rates for PDMS-Mesh also had low variability (relative standard deviation—RSD = 29%) and no relationship with octanol-air partition ratios (KOA). The higher variability for GFF-Mesh (66% RSD) may be due to greater accumulation of particle-phase compounds, as restricting the generic uptake rate to features with log KOA <8.5 log units decreased variability (0.61 ± 0.20 m3 day−1 dm−2, 33% RSD). Compound-specific uptake rates should be used for features measured on GFF-Mesh with log KOA ≥8.5 log units, which are more likely to be particle-associated and not obey diffusive uptake. Through our nontargeted calibration of PDMS-Mesh and GFF-Mesh, we demonstrate a new method for expanding the chemical coverage of calibration studies without relying on additional analytical standards. Calibrating other PASs in different sampling environments using nontargeted analysis will advance our understanding of uptake kinetics, including for novel compounds that cannot be studied in targeted analysis.

Disclaimer/Disclosure: This research was funded by the McMaster University Department of Chemistry and Chemical Biology.

4.01.P-Th158 Multi-Year Non-Targeted Analysis of Environmental Contaminants in Passive Air Sampler Extracts From Montreal Using LC- and GC-Q-TOF-MS

Lan Liu[1], Antoine Gillet[2], Xianming Zhang[3], Frank Wania[4], Géraldine Delbès[5], Philippe Apparicio[6] and Stéphane Bayen[1] (1)McGill University, (2)National Institute for Scientific Research (INRS), (3)Concordia University, (4)University of Toronto, (5)Armand-Frappier Santé Biotechnologie Research Centre, Institut National de la Recherche Scientifique, (6)Sherbrooke University, Department of Applied Geomatics, Sherbrooke, QC, Canada

Air pollution is strongly associated with increased lung cancer incidence and mortality. Many semi-volatile industrial chemicals, pesticides, and combustion by-products are known endocrine disruptors or genotoxic compounds, and exposure to complex mixtures of these contaminants in urban air may contribute to adverse health effects. However, the role of outdoor air pollution in the development of other cancers and chronic diseases remains poorly understood, partly because the chemical composition of airborne mixtures has not been comprehensively characterized. Non-targeted analysis (NTA) using high-resolution mass spectrometry (HRMS) enables broad characterization of environmental contaminants. In a previous study, we developed an NTA workflow to profile chemical mixtures in outdoor urban air using passive air samplers (PASs) deployed at 40 sites across the Island of Montreal, Canada, during summer 2021. 25 molecular features were confirmed using analytical standards.

Here, we expanded this work by deploying PASs at the same 15 public sites during summer 2024 and winter 2025, to assess temporal and spatial trends across three sampling periods. Additional 11 air quality monitoring stations operated by the City of Montreal were included in the 2024 and 2025 campaigns to broaden spatial coverage. Chemicals collected by PASs were extracted and analyzed by LC-QTOF-MS and GC-QTOF-MS. Retrospective data processing and suspect screening were applied to characterize airborne chemical mixtures. Principal component analysis and hierarchical clustering revealed distinct chemical profiles between public sites and air monitoring stations. Several molecular features were consistently detected among the most abundant compounds across multiple sampling campaigns, indicating the presence of persistent and widespread contaminants in the urban atmosphere. Many compounds identified in 2021 were also detected in 2024 and 2025, demonstrating temporal persistence. In addition, the presence of other contaminant classes, including per- and polyfluoroalkyl substances (PFAS), was confirmed using analytical standards. Temporal patterns of previously identified compounds and newly detected features were compared across sampling periods to evaluate changes in urban air chemical mixtures over time. These findings improve our understanding of long-term exposure to airborne contaminant mixtures and provide valuable information for environmental monitoring and human health risk assessment.

4.01.P-Th159 Development and Evaluation of Machine Learning Models To Screen Environmental Risks of Chemical Features Based on Information Gained From Non-Targeted Chromatography-Mass Spectrometry Analysis

Samira Norouzi[1], Paula Gomez Zea[2] and Xianming Zhang[1] (1)Concordia University, (2)Concordia

Mass spectrometry (MS) is widely used to detect and analyze chemicals in complex environmental samples, but

interpreting raw mass spectra for environmental risk assessments remains challenging. In this study, we developed and evaluated machine learning (ML) models based on data obtained from mass spectrometry to predict the persistence, bioaccumulation, and toxicity (PBT) properties of chemicals without resolving their full structures. PyCaret, a Python-based ML package, was used for model development, processing MS data, and comparing multiple algorithms. After hyperparameter tuning and 10-fold cross-validation, the models demonstrated high predictive performance, with test-set accuracies over 0.87. For bioaccumulation and air persistence classification, the Extra Trees Classifier (ET) model showed strong performance, with accuracies of 0.90 and 0.94 and AUC (area under the receiver operating characteristic curve) values of 0.96 and 0.98, respectively. The CatBoost Classifier (CAT) model performed well in classifying both water-persistence and toxicity. It reached accuracy and AUC values of 0.92 and 0.97 for water-persistence, and 0.93 and 0.98 for toxicity. No significant difference (< 6 %) between the accuracy of the training and test datasets suggest that the models are well generalized, with no evidence of overfitting or underfitting during the training process. In all models, several features (fractions) were found to be important for the model's predictive performance. The fractions correspond to the mass-to-charge ratios (m/z) of M+2, M+4, M+5, M-68, and M-70 had a significant impact on the model's ability to classify and predict outcomes accurately. Some of these fractions may be linked to halogens such as chlorine (Cl) or bromine (Br), which produce characteristic isotopic patterns in mass spectrometry. Optimized models were applied to predict PBT properties of chemicals identified through non-targeted analysis (NTA) to assess their applicability in real-world chemical screening. Over 70% of chemicals within the applicability domain were predicted with high confidence (> 0.9) across all models, which supports reliable prioritization of compounds for risk assessment. This work highlights the ability of ML models to connect MS data with chemical risk assessment and provides an approach for predicting chemicals ecological impact even in the absence of complete structural information.

4.01.P-Th160 From Promise To Scale: Integrating Best Practices and Quality Controls Into a Laboratory NTA Workflow

Million Woudneh[1], Bharat Chandramouli[1] and Connnor Taggart[1] (1)SGS AXYS Analytical Services Ltd.

Non-targeted analysis represents a significant emerging mass spectrometric approach for understanding the occurrence, fate and transport of organic contaminants. While the technique itself is not new, the greater availability, sensitivity, ease of use and economic case for NTA has changed significantly to the point that many of the challenges left are less technical. The major challenges facing NTA uptake, especially by commercial laboratories at scale are standardization, expectations and quality frameworks to achieve repeatable, scalable and robust workflows. While the best practices for NTA (BP4NTA) initiative has provided guidance, implementation in repeatable standardized workflows suitable for larger-scale commercialized analysis is still emerging.

In this study, we implement a standard NTA workflow for PFAS using BP4NTA's study reporting tool as a guide. Thirty-six deuterium and ^{13}C labeled standards were used to monitor extraction and quantification performance. Fragmentation quality was evaluated using absolute and normalized stepped collision energies. Data dependent MS^2 (Top4) was acquired in both negative and positive ionization modes to maximize feature coverage. PFAS identification integrated spectral libraries, curated databases, class specific fragmentation rules, and mass defect filtering, with Level1 confidence supported by 108 authentic PFAS standards. Workflow validation employed pooled effluent and biosolid extracts spiked with the same 108 standards spanning diverse

chemical classes and physicochemical properties. Additional isotopically labeled surrogates ensured injection control and quantification of labeled analogs. Semiquantitative concentration estimates were derived from response factors of structurally or chromatographically similar standards and evaluated using available reference standards. The validated workflow was applied to characterize PFAS occurrence and concentrations in influent, effluent, and biosolid samples.

4.01.P-Th161 Suspect and Non-Target Screening of Potential Organic Contaminants Associated With Marine Industrial Discharges

Mangong Shin[1], Hoon Choi[2], Moonjin Lee[2] and Hyo-Bang Moon[3] (1)Hanyang University, (2)Korea Research Institute of Ships and Ocean Engineering, (3)Hanyang Univeristy

Marine industrial facilities can introduce diverse organic contaminants into adjacent coastal environments through operational discharges, yet the composition and environmental occurrence of these contaminants remain insufficiently characterized. Screening of environmental samples collected near discharge outlets can help identify contaminants potentially associated with facility operations and support the prioritization of substances requiring further investigation. This study aimed to investigate potential organic contaminants associated with marine industrial discharges through suspect and non-target screening of surface water and sediment samples collected near discharge outlets. Sampling was conducted from July to September 2024 at eight marine industrial facilities in the Republic of Korea, including four thermal power plants, two nuclear power plants, and two oil refineries. At each facility, ten surface water samples and ten sediment samples were collected in the vicinity of the discharge outlet, resulting in a total of 160 environmental samples. The samples were analyzed using gas chromatography-time-of-flight mass spectrometry (GC-TOF/MS), followed by suspect and non-target screening to characterize detectable organic contaminants and identify substances repeatedly occurring in receiving environments surrounding the industrial discharge outlets. Occurrence patterns were evaluated within and between surface water and sediment samples, as well as among facility types. Frequently detected substances were further examined for their potential association with industrial activities, such as operational use, process-related materials, or discharge-derived inputs. Detection in both surface water and sediment was considered particularly relevant for identifying contaminants potentially introduced through discharge and retained in the surrounding marine environment. This study provides a screening-based framework for identifying candidate organic contaminants potentially associated with marine industrial discharges without restricting the investigation to predefined target analytes. The findings can support the prioritization of emerging contaminants for subsequent confirmation, quantitative monitoring, and source-oriented assessment in coastal receiving environments.

Disclaimer/Disclosure: This study was supported by Korea Institute of Marine Science and Technology Promotion funded by the Ministry of Oceans and Fisheries, Korea (RS-2021-KS211535).

4.01.P-Th162 Multi-Level Characterization of Cyanopeptides and Transformation Products in Freshwater Using Targeted and Non-Targeted Analysis by UHPLC-HRMS

Audrey Roy-Lachapelle[1], Morgan Solliec[2] and Christian Gagnon[1] (1)Environment and Climate Change Canada (ECCC), (2)Ministry of the Environment, the Fight against Climate Change, Wildlife and Parks (MELCCFP)

Harmful cyanobacterial blooms (HCBs) are an increasing concern for freshwater ecosystems and public health,

driven by nutrient runoff from agricultural and urban areas as well as climate change. The hundreds of cyanopeptide congeners produced by cyanobacteria highly exceed the capacity of conventional targeted monitoring, leaving significant knowledge gaps regarding their environmental occurrence, fate, and toxicological risk.

To address this, a multi-step analytical framework combining targeted quantification, suspect screening, and non-targeted analysis (NTA) by UHPLC-Orbitrap HRMS was developed and applied to surface water samples collected during bloom events in agricultural and urban watersheds of southern Québec, Canada. Samples were extracted by solid-phase extraction (SPE) prior to analysis. A targeted method simultaneously quantified 28 cyanopeptides across seven families (microcystins, anabaenopeptins, aeruginosins, microginins, cyanopeptolins, aeruginoguanidine, and nodularin). Suspect screening, using CyanoMetDB, an open-access database compiling over 2600 cyanobacterial secondary metabolites, and in silico fragmentation (FISh scoring), expanded detection beyond targeted compounds. A novel NTA workflow incorporating compound class searches, in silico modeling, and the enviPath biotransformation prediction tool was developed to identify unknown cyanopeptides and transformation products.

Significant microcystin concentrations were detected for the first time in Lac Saint-Pierre, and anabaenopeptins were reported for the first time in the Yamaska River at levels approaching WHO drinking water guidelines. Suspect screening uncovered 26 additional cyanopeptides, including the newly characterized [DMAdda^{5}, GluOMe^{6}]microcystin-LHty, while the NTA workflow led to the identification of seven new transformation products and microcystins. Overall, this study demonstrates that integrating multiple analytical levels significantly expands cyanopeptide detection and characterization, more accurately reflecting the chemical diversity of cyanotoxins and fate in freshwater environments, with direct implications for environmental monitoring and public health safety.

4.01.P-Th163 Targeted and Non-Targeted Screening of POP's (Persistant Organic Pollutants) in Groundwater and Trade Effluent Wastewater Using a Benchtop Mass Spectrometer

Alex Birsan[1], Chris Henry[1], Lindsay Hatch[1] and Naren Meruva[1] (1)Waters Corporation

Persistent Organic Pollutants (POPs) are causing increasing global concern due to their sustained presence in the environment, ability to travel long distances, and capacity to bioaccumulate in the fatty tissues of humans and wildlife. Attempts to mitigate the negative impact of traditional POP’s, e.g. polychlorinated biphenyls (PCB’s), (used in electrical equipment, sealants and paint) and DDT (synthetic insecticide), resulted in the widespread introduction of PFAS (per/perfluoroalkyl substances) as ‘safer’ alternatives. These compounds are now known to also be toxic, persistent and mobile. These concerns have accelerated the need to screen ‘raw’ water sources that may ultimately be used for drinking water for POPs to ensure levels are below regulatory limits. QToF mass spectrometry offers the necessary sensitivity and resolution for both targeted and non-targeted screening of raw water samples.

Two samples of trade effluent water (Wastewater 1/Wastewater 2) and one sample of groundwater were tested. Samples were centrifuged in Eppendorf tubess to remove particulates. 100 µL of each sample supernatant was pipetted into separate polypropylene vials containing 100 µL of diluent (ACN:MeOH, 50:50) with 0.1% formic

acid. A calibration curve was constructed using PFAC30PAR PFAS mix (Wellington Laboratories, Canada) ranging between 0.001 – 50 ng/mL. The samples were analyzed on a QToF mass spectrometer in positive and negative electrospray mode. Initial screening was carried out using a PFAS library within waters_connect with further qualitative data interrogation carried out using the waters_connect Pattern Analysis app.

Data were collected in full scan using a QToF in MSe negative mode, which enables the simultaneous acquisition of both precursor and fragment ions in a single analysis. Initial targeted screening against a PFAS library containing retention time, expected intact masses and known fragments was carried out. The targeted screening concluded that Wastewater 1and 2 contained multiple PFAS species including PFOA (linear and branched), PFHxS, PFHxA, while the groundwater sample contained PFOS (linear and branched), PFHxS, PFBS and PFPeS. Initial screening with the wastewater samples in the Pattern Analysis app showed repeating units of 44.026 consistent with the presence of polyethylene glycol. Also detected in Wastewater 1a repeating unit of mass 49.9968 which corresponds to a CF2 group indicating a PFAS species not found in the target library.

4.01.P-Th335 Calibrating Passive Eyewear Samplers for Assessing Known and Emerging Airborne Contaminants Using Targeted and Non-Targeted Analysis

Jenny Li-Liao[1], isabella pastore[1], Sara Vaezafshar[1], Camille Tsang[2] and Joseph Okeme[1] (1)McMaster University, (2)University of Toronto

Wearable passive air samplers (PASs) are useful tools for assessing personal exposure to air pollutants, which are associated with chronic illness and other adverse health impacts. Since PASs do not measure air volume, we need to calibrate PASs against active air samplers (AASs) to measure equivalent air volume using mass loading from PAS and AAS-measured air concentrations to derive generic uptake rate. However, few wearable PASs have established uptake rates, limiting their use for exposure assessment. To address this gap, our group introduced passive-sampling eyewear as a wearable PAS for assessing personal inhalation exposure. In this study, we calibrated passive sampling eyewear designed to measure personal inhalation exposure to airborne contaminants.

We derived chemical uptake rates for more than 200 features using targeted and nontargeted analysis. To accomplish this, we conducted stationary and mobile calibration studies, where we co-deployed the passive sampling eyewear against an active air sampler for 96 hours. We then characterized inhalation exposure of study participants in office (n = 14) and residential (n = 4) environments using only the calibrated passive sampling eyewear. We analyzed all samples using gas chromatography coupled with an Orbitrap mass spectrometer (GC-MS), operating in positive-ion electron ionization mode (EI). We used RStudio, Compound Discoverer, and ClassyFire for data analysis, feature annotation, and classification. We derived a generic uptake rate of 0.88 ± 0.38 $m^3day^{-1}dm^{-2}$ based on the uptake rates from over 200 features. Our generic uptake rate is comparable with values reported for other calibrated wearable samplers. We applied our generic uptake rate to determine air concentrations and estimate inhalation exposures to airborne contaminants. Across both home and office environments, we observed dibutyl phthalate (DBP), diisononyl phthalate (DiNP), and benzyl butyl phthalate (BBP) at levels comparable to those reported in previous indoor air monitoring studies. Interesting, we detected 14 features with level 2 confidence including 2-mercapotobenzothiazole and benzyl salicylate, which are compounds previously reported in the air in the literature. These findings demonstrate that calibrated passive

sampling eyewear offers a practical and scalable approach for measuring personal exposure to indoor airborne contaminants, enabling inhalation exposure assessment.

Advancing PFAS Forensics and Analysis: Integrating Source Differentiation, Analytical Developments and Regulatory Alignment

4.02.T-01 Septic Systems as a Likely Source of PFAS Contamination of Drinking Water in Rural Maine, USA

Richard Hilliard[1], Emma McDonald[1], Jane Disney[1], Caitlin Oliver-Olsen[1] and Léo Charbonneau[2] (1)Mount Desert Island Biological Laboratory, (2)College of the Atlantic

Per- and polyfluoroalkyl substances (PFAS) are present throughout the environment due to decades of use in many commercial products and industrial processes. PFAS molecules contain a hydrophobic fluorocarbon tail and a functional hydrophilic headgroup. These properties make them inherently resistant to degradation, readily bioaccumulative, difficult to track through the environment, and likely contribute to their toxicities. Through collaboration with town officials, multiple meetings with the local sustainability committee and school groups, and direct contact with individual households and families, this study conducted a community-driven survey of PFAS in groundwater from 105 private wells in a rural Maine community, testing 30 PFAS analytes using EPA Method 537 MOD. The rate of detection across all private wells (N=105) for one or more PFAS analyte was in this municipal scale study was 69%. Of these wells, 17 exceed the interim drinking water standard in the state of Maine and an additional 17 (32% total) will exceed the newly adopted standards for the state once they are phased in. The most frequently detected analytes were perfluorooctanoic acid (62%) and perfluorobutanoic acid (57%) and the highest total PFAS level detected was 159 nanograms per liter from a well with a depth of 300 feet. Both pairwise Spearman's rank correlations and hierarchical cluster analyses of the chemical profiles of analytes reveal distinct groups of 'fingerprints' across this municipality, however these similar sites may be very close to one another or very distant. Additionally, contaminated wells are more often located in the more densely settled areas of this town. Taken together, these findings support septic systems as the primary source of PFAS contamination in groundwater across this rurality. Finally, the importance of water filtration options, long-term management strategies for small municipalities, and focused efforts for future groundwater testing are discussed.

4.02.T-02 Theoretical Forensic Fingerprints From Biodegradation Literature

Kristin Robrock[1] and Tiffany Thomas[1] (1)Exponent

Many PFAS formulations used in industrial and commercial applications consist of unmeasurable precursor PFAS that may degrade under conducive biogeochemical conditions to measurable PFCAs and PFSAs. The degradation patterns of those precursors may provide a forensic signature of their release to the environment. While biodegradation studies specific to those precursors are often not available, studies of structurally similar precursor or intermediate PFAS compounds do exist. A thorough literature review of electrochemical fluorination (ECF)- and fluorotelomer-synthesized precursor PFAS was conducted, focused on bench-scale laboratory studies of individual PFAS compounds exposed to a variety of microbial cultures and degradation conditions, to understand the geochemical conditions that lead to biological degradation. Where reported,

relative molar ratios of PFCA and PFSA degradation products were quantified and other fluorinated intermediary compounds were identified. In general, anaerobic biodegradation studies did not yield sufficient degradation products and many aerobic studies did not provide quantifiable data for those studies to be included; therefore only a subset of the available literature could be used. Additionally, there is variability in molar ratios of biodegradation products among the various microbial cultures studied. A range of theoretical degradation profiles under aerobic environmental conditions was compiled for ECF and fluorotelomer precursor chemistries. These theoretical degradation profiles may be used as potential fingerprints to identify the presence of specific precursor chemicals in the environment.

4.02.T-03 Crowdsourcing To Spatially Map Differences Between Targeted PFAS and Total Absorbable Organic Fluorine and To Identify Emerging Drug Threats in the Tampa Bay Estuary and Adjacent Waterways

John Bowden[1], Thomas Sinkway[1], Esmee Belzer[2] and Graham Peaslee[2] (1)University of Florida, (2)University of Notre Dame

Tampa Bay (Florida, USA) has a long history of pollution due to its high anthropogenic presence in the surrounding area. As the bay is utilized for food, agriculture, recreation, and tourism, these sources of pollution pose great risks to the environment and to the communities of the region. Limited research has been conducted in this area accessing the PFAS landscape. This study screened surface water samples (n=511) for 28 PFAS, via a targeted methodology, utilizing solid-phase extraction and analyzed via high-performance liquid chromatography-tandem mass spectrometry (HPLC-MS/MS). Each sample site also had a corresponding total adsorbable organic fluorine analysis conducted, with extraction using granular activated carbon (GAC) felts and analyzed via particle-induced gamma-ray emission spectroscopy (PIGE). The surface water was obtained using a crowdsourcing strategy that created a high-resolution map of sampling points across the entire Tampa Bay region. This community-driven sampling effort allowed for a detailed spatial representation of each PFAS species by both presence and concentration. Additionally, this study allowed for the comparison of the two workflows to identify potential PFAS gaps inherent with current targeted strategies. Overall, this study provided potential sources of pollution, in addition to locating potential sites for further PFAS exploration to be conducted. Finally, this study also focused on measuring 28 illicit drugs (and select metabolites) and 26 pharmaceuticals in parallel samples collected at each site, to spatially map the presence of emerging drug threats within the bay. Comparisons between PFAS and drug patterns highlight several potential in-common sources, while also highlighting those sources which were chemical specific. Comparison of both analyses also highlights vulnerable areas in the bay that require more attention for future mitigation and remediation efforts.

4.02.T-04 "Is It Ours?" Incorporating New Lines of Evidence in a Multiple Lines of Evidence Approach to PFAS Forensics

Tom Wanzek[1] (1)Geosyntec Consultants

One of the main questions about PFAS detections in environmental media is not “if they’re detected” but “when they’re detected”, what should be done? Developing a defensible conceptual site model (CSM) is critical to identifying potential PFAS sources, establishing timely and effective response(s), and employing appropriate monitoring or remediation strategies. One of the most pressing questions to answer is: did this come from use of PFAS-containing materials on site (e.g., AFFF use), equipment/operations, or is it attributable to an offsite

source or regional background contamination? The proper application of PFAS fingerprinting tools (chemical and data analytics) can be a powerful line of evidence when faced with questions from regulators. This presentation will discuss a tried and true multiple lines of evidence approach to developing a strong CSM; including establishing the nature and extent of PFAS at a site, a scientifically sound understanding of PFAS fate and transport properties, establishing site and alternative source histories, and appropriate applications of chemical forensic tools.

4.02.T-05 PFAS in the Delaware River Basin: An Accidental Discovery and Industrial Might Have Created a Burgeoning Environmental Calamity

Jeremy Conkle[1] and Matthew Amato[2] (1)Delaware River Basin Commission (DRBC), (2)Delaware River Basin Commission

The Delaware River Basin (Basin) is ground zero for PFAS pollution. The first fluoropolymer, polytetrafluoroethylene (Teflon), was accidentally synthesized on the banks of the Delaware River in 1938. This discovery ignited decades of intensive commercial manufacturing, widespread industrial applications, and ubiquitous consumer use of PFAS chemicals. This group of over 13,000 chemicals remained in the background, relatively unknown, for half a century until advances in analytical methods enabled the detection of widespread PFAS pollution. The Delaware River Basin Commission (DRBC) began PFAS monitoring in the mid-2000s, providing some of the earliest data in the Basin. Currently, over 20 years of PFAS data exist, with 85% collected since 2019. Based on publicly available data, PFAS have been detected in 87.8% of samples across surface water, groundwater, sediment, and biological tissues; in water alone, the detection rate is 93.1%. The stretch from Trenton, NJ, to Wilmington, DE, has been intensively monitored relative to other locations and consistently exhibits the highest concentrations in the river's mainstem. While resolving PFAS pollution may span decades, recent sediment core analyses indicate that PFAS levels began increasing in the mid-1950s—highlighting PFAS as a problem in the Basin for over 70 years. Aided by our growing knowledge of PFAS pollution in the Basin and the overwhelming evidence of their adverse impacts on humans and wildlife, DRBC is reviewing all available information with the ultimate goal of identifying PFAS data gaps, tracing their sources, and correcting 70 years of PFAS pollution in the Delaware River Basin.

4.02.T-06 Dimensionality Reduction for PFAS Fingerprinting and Source Attribution – Communicating Anthropogenic Signals in Complex Backgrounds

Mike Dereviankin[1] (1)Montrose

Introduction: Environmental practitioners frequently encounter PFAS-impacted sites where anthropogenic sources such as aqueous film-forming foams (AFFF) overlap with diffuse regional background contamination from consumer products, industrial releases, and atmospheric deposition. Distinguishing these sources is critical for liability assessment and remedial design, yet communicating the complexity of high-dimensional PFAS fingerprints to stakeholders, regulators, and legal audiences remains challenging. Traditional analytical approaches struggle to convey relationships between dozens of PFAS analytes in a manner accessible to non-technical audiences, particularly when precursor compounds and transformation products obscure stable marker patterns.
Method: Uniform manifold approximation and projection (UMAP) was applied to multi-site PFAS datasets to visualize source-specific patterns in reduced dimensional space. The approach was designed to separate AFFF-

related fingerprints from regional background signatures while preserving the underlying structure of compound relationships. Site-specific datasets included both stable terminal products (e.g., PFOS, PFOA) and precursor species to evaluate how transformation dynamics influence the visual separation of source categories and the clarity of forensic interpretations.
Results: UMAP successfully delineated AFFF-impacted samples from regional background profiles, revealing distinct clustering patterns that corresponded to known source histories. The inclusion of precursor compounds and short-chain species such as PFBA introduced variability within source clusters, reflecting environmental transformation processes that alter fingerprint composition over time. This visualization framework enabled clear communication of source attribution findings to stakeholders by translating complex multi-analyte datasets into interpretable spatial relationships.
Conclusion: Dimensionality reduction through UMAP provides a practical and accessible tool for PFAS source attribution, particularly in scenarios where anthropogenic inputs must be differentiated from complex regional backgrounds. This approach supports forensic assessments by incorporating precursor transformation pathways into visual interpretations, improving both analytical rigor and stakeholder communication in environmental investigations.

Advancing PFAS Forensics and Analysis: Integrating Source Differentiation, Analytical Developments and Regulatory Alignment

4.02.P-Tu192 Dispersive Liquid–Liquid Microextraction (DLLME) for Rapid, Cost-Effective Automated PFAS Extraction and Cleanup Across Environmental Matrices

Bénédicte Gauriat[1], Aristide Ganci[1], Jean-François Garnier[1] and John George III[1] (1)Thermo Fisher Scientific

Per- and polyfluoroalkyl substances (PFAS) are widely distributed across environmental media, including water, soils, sediments, and aquatic organisms. Regulatory drinking water methods rely on solid-phase extraction (SPE), which is labor-intensive and not optimized for rapid, large-scale monitoring efforts. The objective of this work is to evaluate automated dispersive liquid–liquid microextraction (DLLME) as a high-throughput, non-regulatory sample preparation approach for PFAS analysis in environmental surveys requiring fast turnaround and large numbers of samples.

An automated DLLME workflow was applied to a range of environmentally relevant matrices, including drinking water, groundwater, surface water, wastewater, soils, sediments, industrial effluents with high dissolved solids, and fish tissue. DLLME integrates extraction, concentration, and cleanup into a single automated process using small sample volumes and less than 2 mL of organic solvent per sample, without cartridges or filtration. Sample preparation is performed under full robotic control, enabling unattended operation and consistent processing of mixed-matrix batches. Following extraction, PFAS are analyzed using EFOX (Environmental and Food Organic Xenobiotics)-enabled LC-MS systems. Targeted quantitation is performed using either the TSQ Altis™ Plus EFOX Edition triple quadrupole mass spectrometer or the Orbitrap Exploris™ EFOX mass detector operating in full-scan high-resolution mode with accurate-mass extracted ion quantitation.

Across the matrices evaluated, DLLME-generated data demonstrated strong analytical performance using an

extracted calibration approach, in which all calibration standards undergo the same extraction process. This strategy avoids the need for explicit recovery calculations while ensuring matrix-consistent quantitation. Matrix effects are therefore assessed relative to a clean water reference extracted under identical conditions. The workflow supports quantitation at environmentally relevant levels, including low part-per-trillion concentrations (sub-ng/L to tens of ng/L) in water matrices and low ng/kg to low µg/kg levels in solids and fish tissue. Automated DLLME coupled with EFOX-based targeted and high-resolution detection supports efficient analysis across diverse environmental and aquatic matrices while greatly reducing solvent use, consumables, and manual handling.

4.02.P-Tu193 Analytical Bias as a Forensic Challenge in PFAS Measurements in Fish Tissues

Gabriel Munoz[1], Karima Hadria Gondry[2], Martin Duchesneau[1], Karine Lessard[1], Paloma Marestay[1], Sabrina Simard[1], Sébastien Côté[1] and Marie-Claire Grenon[1] (1)CEAEQ, MELCCFP, (2)INRS

Per and polyfluoroalkyl substances (PFAS) have been extensively monitored in fish tissues due to the bioaccumulation potential and health concerns associated with long-chain compounds, sometimes leading to fish consumption advisories. PFAS profiles measured in fish tissues and other environmental compartments are also useful to assess spatial trends and partitioning. However, the extent to which analytical biases influence PFAS fingerprints in biological matrices remains insufficiently documented. Here, we present a comprehensive evaluation of multiple bias sources that can compromise accurate PFAS determination in fish tissues by liquid chromatography tandem mass spectrometry (LC-MS/MS). Using naturally contaminated fish samples, we investigated the influence of matrix state (fresh vs. lyophilized tissues), tissue rehydration, mechanical grinding, extraction solvent nature, and purification strategies on PFAS recoveries and matrix effects. Commonly used pre-treatment methods led to substandard recovery of specific PFAS classes, and purification strategies had a variable influence on matrix effect removal and target PFAS loss. Natural endogenous interferents, including bile acids, γ carboxyethyl hydroxychroman and medium chain fatty acids, were also evaluated for their potential to artefactually inflate PFAS concentrations. These analytical biases can directly influence whether samples are considered compliant with existing guidelines. By explicitly identifying and quantifying these biases, the study provides a framework to strengthen PFAS biomonitoring methods.

4.02.P-Tu194 Development of Robust GC-MS/MS Analytical Method for Determination of Alkylamine Compounds Belongs to PFAS (per- and Polyfluoroalkyl Substances) in Plasma

Alpeshkumar Patel[1], Basheer Shaikh[1], Purushottam Trivedi[1] and Nadeem Khan[1] (1)Jai Research Foundation (JRF)

Accurate quantification of alkylamines and fluorinated compounds particularly per and polyfluoroalkyl substances (PFAS) in complex matrices such as environmental and biological samples remains challenging. This difficulty arises from their wide-ranging physicochemical characteristics, strong polarity, and, in the case of fluorocarbons, notable thermal stability. In this work, a reliable, highly sensitive, and selective analytical approach using gas chromatography coupled with tandem mass spectrometry (GC–MS/MS) is proposed for the simultaneous or complementary analysis of these target compounds. The limited solubility of certain alkylamine-related PFAS in polar solvents restricts their effective determination using LC–MS/MS techniques.

Some of the analytes PFAS molecule associated fluorocarbon groups, the which are better characterized through targeted analysis of volatile compounds and their precursors. Liquid–liquid extraction (LLE) technique was used for efficient analyte isolation and sample cleanup. DB-624 capillary column is used for the chromatographic separation of analyte under oven-temperature programming to reduce analysis time as well as better resolution. The analysis is carried out using tandem mass spectrometry in multiple reaction monitoring (MRM) mode for selectivity and better sensitivity. The calibration curve is established using concentration range 10 - 2500 µg/L with correlation coefficient is > 0.99, and precision is < 10%. Analytical method is accurate and robust as the recovery range was between 80 - 115%. GC–MS/MS based approach offers a cost-effective and high-throughput alternative to LC–MS-technique, providing selectivity for fluorocarbon classes and detection of amines. This method is applicable for applications in environmental and regulatory assessment.

Keywords: PFAS, GC-MS/MS, LLE (Liquid-liquid extraction) and plasma.

4.02.P-Tu195 Analysis of PFAS in Human Biological Matrices (Blood) by UHPLC-HRMS and Human Exposure Assessment

Adam Rochepeau[1] (1)University of Montreal

Per- and polyfluoroalkyl substances (PFAS), include a large class of synthetic molecules. They are found in almost all natural environments: surface water, groundwater, soil, air, etc. They have the property of accumulating in living organisms and amplifying along trophic chains. A growing number of studies support hypotheses that PFAS cause long-term negative health effects. Among human exposures, the most important are occupational exposures.

Accurately measuring exposure to PFAS is a public health issue. The most studied matrices for exposure measurements are blood matrices (whole blood, serum or plasma). Among them, dried whole blood samples seem to show many advantages for measuring PFAS exposure in adults.

This work aims to develop methods for targeted PFAS analysis by high-performance liquid chromatography coupled with high-resolution mass spectrometry (HPLC-HRMS) in human biological matrices and particularly dried whole blood. The development, optimization and validation of the methods will include all the steps inherent in analytical chemistry: from sample collection to statistical interpretation of the results. Thanks to these new methods, exposure measurement work in different populations will be carried out.

4.02.P-Tu197 Using Molecular Community Networks To Reveal the Diverse Complexity of PFAS

Andrew Roberts[1], Alexander Landry[1], Elizabeth Coler[1], Sara Nason[2], Jeremy Koelmel[3] and Alexander Aksenov[1] (1)University of Connecticut, (2)Connecticut Agricultural Experiment Station, (3)Yale University

Per- and polyfluoroalkyl substances (PFAS) are a major environmental and health concern. Their incomplete characterization, chemical stability, and structural diversity hinder the development of comprehensive mass spectrometry (MS) spectral libraries. Additionally, the lack of a distinct fluorine isotope and the high energy needed to fragment the fluorine-carbon bond presents another challenge for MS applications. Molecular community networks (MCNs) can visualize structural similarities among compounds within a dataset by

clustering features based on mass spectral similarity. This tool is useful for proposing annotations for structurally related compounds when library matching is not possible. Here, we demonstrate that MCNs, when paired with MS-based in silico prediction tools such as SIRIUS and FluoroMatch, provide a novel and effective approach for characterizing PFAS distributions in environmental datasets. This approach was validated using MassBank spectral library data and MS datasets from PFAS-contaminated soil from aqueous film-forming foam (AFFF), and household dust samples. The MCN generated from the combined PFAS-contaminated datasets showed that PFAS formed communities according to both subclass and sample matrix. Fluorotelomers, along with several carboxylic acids and their derivatives, formed one community. Perfluorosulfonic acids and their derivatives formed another, with several features originating from the AFFF soil samples. Perfluorocarboxylic acids and perfluorosulfonamides, together with their derivatives, formed the final major community, with most features derived from the dust dataset. Furthermore, edges (connections between features) can identify PFAS-related fragments based on their mass differences. PFAS-related edges were abundant within the communities described above and largely absent from non-PFAS communities. This approach helps visualize the "dark matter" of PFAS that cannot be confidently identified through conventional spectral library matching. Overall, this method will support the detection and characterization of PFAS compounds in both future and existing datasets.

Disclaimer/Disclosure: AAA was supported by the USDA NIFA GRANT 2022-70029-38489.
AAA is a cofounder of Arome Science, BileOmix and GreenScent Inc.

4.02.P-Tu198 Comparison of per- and Polyfluoroalkyl Substances (PFAS) Concentrations in Synthetic Field Turf Components to Background Soil and Rainwater PFAS Levels

Catalina Restrepo Galvis[1], Michael Peterson[1], Kim Reid[1] and Stephanie Kukolich[1] (1)Gradient

PFAS have been used historically as processing aids in the production of synthetic turf products, which has led to concerns regarding potential human and environmental exposures. Today, however, many synthetic turf manufacturers are proactively reformulating and testing their products to ensure that PFAS are not used intentionally during the manufacturing process. To better understand and monitor the effectiveness of product reformulation, Gradient assisted in designing a testing program for various synthetic turf products (i.e., fibers and backing) and other turf components to determine whether targeted PFAS and organic fluorine may be present. Currently, there are no final validated analytical methods designed specifically to test synthetic field turf materials, and the definition of "intentionally added PFAS" varies significantly across the various regulatory agencies. Thus, Gradient selected a suite of analytical methods to encompass a broad range of potential PFAS that may be present in the turf materials, including Environmental Protection Agency (EPA) Method 1633 – for targeted PFAS analysis – and total fluorine via combustion ion chromatography (TF via CIC), followed by inorganic fluorine (IF) (Method 121,4500F-BC) to calculate total organic fluorine (TOF). Additionally, the turf materials were subjected to a synthetic precipitation leaching procedure (SPLP), followed by EPA Method 1633 and adsorbable organic fluorine (AOF; EPA Method 1621) testing to simulate the potential leaching of PFAS and organic fluorine chemicals out of the turf and into soil and groundwater. Since the analytical method suite included two extraction methods and five analytical methods, we were able to generate a robust data set that combined both targeted PFAS and non-specific fluorine analyses in both solid and aqueous media. The results were then compared to background soil and groundwater concentrations published in the scientific literature, as well as the available regulatory standards for consumer products.

Testing results indicate that trace levels of targeted PFAS compounds – likely from environmental contamination and/or use of recycled materials – can be detected in some synthetic turf components; however, these levels are similar to background levels observed in soil and rainwater. In general, organic fluorine testing found PFAS levels in the synthetic turf components to be well below existing regulatory standards for consumer products.

Disclaimer/Disclosure: This work was funded by FieldTurf. The authors have sole responsibility for this work, and the conclusions are those of the authors.

4.02.P-Tu199 Data Interpretation and Best Practices for the Total Oxidizable Precursor Assay: Insights From Controlled Studies and Multi-Laboratory Collaboration

Tammy Chartrand[1] and Heather Lord[1] (1)ALS

The Total Oxidizable Precursor Assay (TOP Assay) is often used to detect per- and polyfluoroalkyl substances (PFAS) precursors not identified through conventional analytical methods. This assay transforms complex PFAS into measurable perfluorocarboxylic acids (PFCAs) via oxidative degradation. Despite its utility, care needs to be taken with data interpretation of TOP-Assay results due to indirect transformation products, oxidative transformation conditions, incomplete recoveries, transformation to species outside of routine suites, and the non-standardized nature of methods across laboratories.

This presentation will explore the practical applications of the TOP assay including decontamination and foam transition to provide meaningful data to determine critical insight into the total PFAS burden associated with the historical use of aqueous film forming foams (AFFF).

Results from single component spikes that were subjected to TOP assay will be presented, including monitored recoveries and transformation products to 60 unique PFAS compounds. As expected, mass balance was not seen for any of the converted precursors, however trends for different groups of PFAS were noted.

Details of a multi lab collaborative study across six ALS laboratories will also be shared, with the objective to identify best practices for a Total Oxidizable Precursors (TOP) Assay, to improve data quality and interlaboratory reproducibility. The study included 58 individual PFAS including all EPA Method 1633 target PFAS and both aqueous and soil matrices.
Despite limitations and challenges associated with this technique, leading international PFAS environmental management programs (such as Australia's National Environmental Monitoring Program) stress the importance of incorporating qualitative tests into environmental assessments to consider the likely total mass and distribution of all PFAS present, using techniques such as the Total Oxidizable Precursor (TOP) and TOF, to provide multiple lines of evidence for informed risk assessments and management decisions.

4.02.P-Tu200 A Love Letter to PFAS Testing: Understanding How Our Lives Are Impacted

Toby Astill[1] (1)Phenomenex

Per- and polyfluoroalkyl substances (PFAS) are persistent contaminants detected across water, food, consumer products, industrial systems, and biological matrices, creating demand for highly sensitive and contamination-controlled analytical workflows. As global regulatory requirements expand and intensify, laboratories across environmental, governmental, academic, contract, industrial, food, and clinical research settings must quantify PFAS in diverse matrices including drinking water, wastewater, soil, sediment, biosolids, tissue, and food. Accurate GC- and LC-MS/MS analysis depends on robust extraction, effective cleanup, and control of background interference at trace levels. Phenomenex PFAS-focused sample preparation and chromatographic technologies support these needs through method-aligned workflows. Strata PFAS stacked SPE and Strata-X-AW weak anion-exchange SPE support extraction and cleanup for applications including Health Canada, EU, EPA 1633, EPA 533, and EPA 537.1, while columns such as Luna Omega PS C18 and Gemini C18 provide reproducible separations for PFAS determination by LC-MS/MS. Framed as a "love letter" to PFAS testing, this presentation recognizes the scientists and their collaborations, regulatory methods, and SPE and column technologies that transform invisible exposure risks into actionable knowledge—showing how advances in sample prep and separation science help laboratories worldwide protect public health, guide environmental stewardship, and better understand how PFAS impact modern life.

4.02.P-Tu201 Putting the (Atmospheric) Pressure On Forever Chemicals: A Targeted Analysis of GC Amenable PFAS Using APGC–MS/MS

Alex Birsan[1], Kari Organtini[1], Naren Meruva[1], Kenneth Rosnack[1] and Kevin Stup[1] (1)Waters Corporation

Analysis of per- and polyfluoro alkyl substances (PFAS) is routinely performed by laboratories around the globe using liquid chromatography coupled to mass spectrometry. This technique is sufficient to cover an extensive list of compounds, but is not well suited for analysis of more volatile classes of PFAS, such as fluorotelomer alcohols and acrylates, among others. As focus continues to expand beyond the routinely monitored compounds and matrices, the addition of gas chromatography coupled to mass spectrometry is becoming an important tool to get a more comprehensive overview of the PFAS composition of a sample. Many of the GC amenable PFAS can be present in a variety of sample types from environmental to food and food packaging.

A method was developed using atmospheric pressure gas chromatography (APGC™) to chromatograph and ionize the GC amenable PFAS of interest. This technique uses nitrogen to ionize the compounds of interest, which is a soft ionization process, allowing for precursor ions to remain intact in the ion source. To simplify laboratory implementation, nitrogen was also utilized as the carrier gas for this separation. Environmental samples were previously extracted for LC-MS/MS analysis using procedures outlined by EPA 1633. The same samples were analyzed using the APGC-MS/MS method without any further sample preparation necessary.

An APGC-MS/MS method was successfully developed to separate and detect 35 different native PFAS compounds, plus four isotope labelled internal standards. The method covered PFAS compound classes including fluorotelomer alcohols, acrylates, methylacrylates, sulfonamides, sulfonamidoethanols, and acetates.

The use of the APGC allowed for the precursor to remain as the intact [M+H] + ion, increasing specificity, as compared to a harder ionization technique like electron ionization, in which these compounds are likely to easily fragment. Detection limits were compound dependent, ranging from 25 –500 ng/mL. Environmental samples, previously extracted following EPA Method 1633 and characterized only using LC-MS/MS analysis, were now analyzed using the developed GC-MS/MS method to determine if any of the targeted GC amenable PFAS were present in the samples. Soil, water and fish tissue extracts were analyzed and GC amenable PFAS were detected and quantified in some of the samples, including fluorotelomer alcohols detected in soil samples.

4.02.P-Tu202 Factors Affecting the Octanol/Water Partitioning of Ionic per- and Poly-Fluoroalkyl Substances

Will Backe[1], Henry Sluka[2] and Ian Mundy[1] (1)U.S. Environmental Protection Agency (US EPA), (2)SpecPro Professional Services, Duluth, MN

The octanol/water partitioning coefficient (Kow) is a widely used chemical property for predicting a compound's fate and transport in the environment. Understanding the variables that affect the Kow of ionic per- and poly-fluoroalkyl substances (PFAS) can help deconvolute the differential migration of PFAS in contamination plumes.

Models that predict the Kow of neutral compounds are well established and can be used with a relatively high degree of confidence. In contrast, model predictions and compiled literature values for ionic compounds can be highly variable and may assume neutrality. For example, predicted log D7.4 (log Kow at pH 7.4) estimates for ionic PFOA range from -3.98 to 1.83 and values compiled from literature range from 2.37 to 4.23 (DTXSID40892486; CompTox Chemicals Dashboard v.2.8.0). These inconsistencies are likely due to uncertainties in ionization state, surfactant nature of PFOA, and that models are not well-trained with highly fluorinated compounds.

In an effort to experimentally derive reliable Kow values for ionic PFAS, slow stir experiments (OECD Slow Stir Method 123) were performed with perfluoroalkyl carboxylates (C6, C8, C10), perfluoroalkyl sulfonates (C6, C8, C10), perfluoroalkyl sulfonamides (C4, C6, C8; likely non/partially ionic), and polyfluoroalkyl telomer sulfonates (n = C6:2 and C8:2). Additionally, the effects of solute concentration, ionic strength, salt composition, pH, and branched isomerization were explored. Results of this work demonstrate that, in practice, the octanol/water partitioning of ionic PFAS depends on several factors including chain-length, solute concentration, ionic strength and composition, pH, and isomeric branching. For example, as concentration in the water increases, the Kow of ionic PFAS decreases likely due to the formation of water-soluble aggregates. As a specific example, the log Kow of PFOA increases log-linearly from 0.77 to 1.4 as its concentration is reduced from 60 µg/L 0.81 µg/L. Alternatively, increasing water salinity increased Kow as ion-pairing mechanisms reduce the charged character of ionic PFAS. To date, few studies have evaluated these factors systematically.

This abstract does not necessarily reflect U.S. E.P.A. policy.

4.02.P-Tu203 PFAS Leaching Tests on Borehole Cores Using the Rapid Leaching Method and Comparison of Results With Conventional Methods

Go Inoue[1], Yoshinori Yabuki[2], Hidenori Matsukami[3] and Satoshi Mizutani[4] (1)Okinawa Prefectural Institute of Health and Environment, (2)Research Institute of Environment, Agriculture and Fisheries, Osaka Prefecture, (3)National Institute for Environmental Studies (NIES), (4)Osaka Metropolitan University

Currently in Japan, soil leaching tests conducted in accordance with the provisional method established by the Ministry of the Environment require six hours of shaking. At last year's SETAC 46th conference, we verified the leaching rate when using a rapid leaching test method with a vortex mixer. Since the leaching volume reached a steady state in an extremely short time, we fixed the leaching time at 1 minute, conducted leaching tests using borehole cores, and compared the results with those obtained using the 6-hour shaking method specified in the provisional leaching test method.
As a result, it was confirmed that there was no significant difference in dissolution concentration between the 6-hour shaking method and the 1-minute vortex mixer method. However, regarding the membrane filters used for filtration, while the amount of adsorption varied depending on the filter material and the type of PFAS compound, it was confirmed that a significant amount of the compounds was adsorbed onto the filters. In Japan's provisional leaching test method, centrifugation and filter filtration are performed after the leaching operation, followed by the addition of a surrogate; it was confirmed that this can result in significant errors depending on the type of filter or PFAS. Therefore, we decided to add the surrogate after centrifugation following the leaching operation and to recover the target substance and surrogate adsorbed onto the filter by rinsing the membrane filter with a solvent after filter filtration.
In this study, we used this method to generate contour plots; while the conventional method requires considerable time and expense to create contour plots, this method allows for their generation with minimal effort and cost.For example, we measured soil leaching at 12 locations on this occasion; it took only half a day from the leaching test to preparing the samples for the LC/MS, and around only one day for all the measurements to be completed.
Furthermore, when we used this method to determine the elution concentrations of PFOS and other long-chain compounds along the depth of the borehole core, we confirmed that contamination was limited to the shallow layers, consistent with the results of previous studies.

Disclaimer/Disclosure: This research was supported by the Environment Research and Technology Development Fund [3-2603(1) (3): JPMEERF20263003] of the Environmental Restoration and Conservation Agency (ERCA) of Japan.

4.02.P-Tu204 Linear and Branched PFAS Isomers: Addressing Challenges in Environmental Quantitation

Chris McCooeye[1], Dan Biggerstaff[1], HuiChen Stavros[1], Jens Seltmann[1], Kelly Cheshire[1], Brian Pike[2] and Philip Bassignani[2] (1)LGC Standards, (2)Pace Labs

In contrast, to the currently used telomerization process, many legacy per- and polyfluoroalkyl substances (PFAS) were manufactured using electrochemical fluorination (ECF), a process that produced mixtures of linear and branched isomers. As a result, environmental contamination frequently reveals complex isomer distributions rather than the predominantly linear compounds commonly used as analytical calibrants. Despite

this, routine environmental measurements are often based on quantitation using linear isomer standards alone. Accurate determination of total PFAS concentrations is complicated by differences in chromatographic behaviour, ionization efficiency, and fragmentation patterns among linear and branched isomers during liquid chromatography-mass spectrometry (LC-MS) analysis. These differences can influence measured response factors and introduce uncertainty into quantitative results when environmental samples contain significant proportions of branched isomers. Furthermore, growing evidence suggests that PFAS isomers may exhibit differing environmental fate, bioaccumulation, and toxicological properties, increasing the importance of isomer-specific characterization.

This study evaluates LC-MS performance characteristics for selected linear, monomethyl-branched, and dimethyl-branched PFAS isomers. Comparisons of chromatographic retention, instrument response, and fragmentation behaviour were conducted to assess the impact of isomer structure on analytical measurement. Results demonstrate significant differences between isomer classes, highlighting challenges associated with the quantitation of environmentally relevant PFAS mixtures using linear isomer calibrants alone.

Addressing these challenges requires improved characterization of branched PFAS isomers and the development of analytical reference materials that better reflect environmental contamination profiles. The data presented provide insight into isomer-specific analytical behaviour and support efforts to improve quantitative accuracy, method harmonization, and future evaluation of the environmental and toxicological significance of PFAS isomer composition.

4.02.P-Tu205 Analysis of PFAS in Dust and Air by HPLC-MS and GC-MS

Celine Zambakjian[1] (1)Université de Montréal

Per- and polyfluoroalkyl substances (PFAS) are a large group of persistent environmental contaminants widely used in consumer products and building materials. Indoor environments are increasingly recognized as important sources of human exposure, particularly through dust and air. This study aims to evaluate the presence and distribution of PFAS in indoor dust samples collected from residential apartments in Montreal, Canada, and Lyon, France. A total of dust samples was collected from 50 apartments in Montréal and 30 apartments in Lyon. Dust samples were obtained from the contents of household vacuum cleaner bags. Samples were subjected to solid–liquid extraction using ultrasonic-assisted extraction and pressurized solvent extraction methods. Analytical quantification was performed using ultra-high-performance liquid chromatography coupled to high-resolution mass spectrometry (UHPLC-HRMS), allowing the analysis of 79 PFAS compounds. Information on several household factors, including floor covering type, presence of carpets, and pets, was collected through questionnaires distributed to participants during dust sampling and will be used to evaluate their potential influence on PFAS concentrations.

PFAS concentrations were compared across different indoor environments, a total of 10 dust samples collected in Canada were analyzed. Preliminary results showed that the average concentration of the 79 targeted PFAS was 113.6 ppb, with the sulfonamide group (EtFOSAA, MeFOSAA, and bistriflimide) being the dominant class, accounting for 61% of total PFAS. The analytical method was validated in terms of linearity, limits of detection (LOD) and quantification (LOQ), recovery, precision, and accuracy, all yielding acceptable performance. LOD values ranged from 0.01 to 1.1 ppb.

Future work will focus on the analysis of PFAS in indoor air samples to provide a more comprehensive assessment of exposure pathways, using different sampling approaches (active sampling, passive sampling, Coriolis air sampler). Depending on the sampling method, appropriate analytical techniques will be selected,

including gas chromatography–high-resolution mass spectrometry (GC-HRMS) for the gaseous phase and UHPLC-HRMS for the particulate phase.

4.02.P-Tu206 PFAS Characterization From Fabrics As Potential Sources of Human Exposure

Le Thanh Dien Nguyen[1], Thomas Mahovsky[1], Rachel McQueen[1] and Shira Joudan[1] (1)University of Alberta

Per- and polyfluoroalkyl substances (PFAS) are a large class of environmental contaminants of concern due to potential toxicity and bioaccumulation. Human exposure to PFAS comes from many sources. An understudied source is sidechain fluorotelomer-based polymers (FTPs), which have been used as surface protectors in textiles products. Exposure to small molecule PFAS, which are more readily inhaled or absorbed compared to polymeric PFAS, may arise from monomer residues or chemical ageing of FTPs. Monomers for FTP production include the semi-volatile fluorotelomer methacrylates (FTMAc) and fluorotelomer acrylates (FTAc). The purpose of this research was to quantify small molecule PFAS from fabric for implications on human exposure and as a proxy for understanding the FTPs coated on the fabrics. Eleven semi-volatile PFAS (4:2-10:2 FTAc, FTMAc and fluorotelomer alcohols (FTOH)) were analyzed by gas chromatography-mass spectrometry and 31 non-volatile PFAS, including C4-C14 perfluoroalkyl carboxylic acids (PFCAs), were analyzed by liquid chromatography-mass spectrometry. Despite the relevance of FTP-coated textiles, most literature does not report FTAc or FTMAc concentrations. The studied textiles were composed of five fabrics with known PFAS information, and 41 purchased fabrics in four separate categories: upholstery, appliance covers (tablecloths, bags, mattress protectors), outerwear (raincoats, rain pants, windbreakers) and non-outerwear clothes. Preliminary results from 31 fabric samples report 6 semi-volatile PFAS and 27 non-volatile PFAS above the limits of quantification. 6:2 FTMAc and 6:2 FTOH account for more than 87% of the total measured PFAS mass. C4-C6 PFCAs comprise more than 60% of the total measured non-volatile PFAS mass. This prevalence of C6-containing small molecule PFAS suggests 6:2 fluorotelomer-based FTPs are present on many fabrics. Furthermore, the presence of C4-6 PFCAs indicates oxidation from 6:2 FTOH, monomer 6:2 FTMAc and 6:2 fluorotelomer-based FTPs. Results also suggest that materials designed for outdoor use contain more PFAS (>400 ng/g) than other fabrics (<10 ng/g). Total PFAS per gram of fabric can be up to 1.80 μg for an outerwear jacketing, and up to 2.92 μg (of which 1.71 μg is 6:2 FTMAc) for an outdoor uphostery material. Results presented will include data of all 46 fabric samples, and will improve our understanding of the sources of PFAS indoors by considering the often-ignored monomer residues from FTP-coated fabrics.

4.02.P-Tu207 Downstream Transport of Legacy PFAS in Surface Waters Adjacent to a Former Air Force Base

Sarah Webb[1], Colin Dobson[1], Karimot Shobowale[1] and Jennifer Bouldin[1] (1)Arkansas State University

Per- and polyfluoroalkyl substances (PFAS) are persistent contaminants associated with historical aqueous film-forming foam (AFFF) use at military installations. Eaker Air Force Base (EAFB) in northeast Arkansas operated until 1992 and is a potential source of PFAS to surrounding waterways. Little information is available on PFAS transport and precursor occurrence in surface waters of the Lower Mississippi Alluvial Valley. This study measured PFAS concentrations and evaluated evidence of precursor transformation in surface waters surrounding EAFB. Fifteen surface-water sites were sampled across drainage ditches, an on-base lake, and the

Little River main channel. Samples were analyzed for target PFAS using EPA Method 1633. A Total Oxidizable Precursor (TOP) assay was conducted at a reference site, a highly contaminated site, and a downstream site to assess the presence of oxidizable precursors. Site elevations and flow direction analyses were used to evaluate likely transport pathways. Target PFAS were detected at all sampling locations. Reference sites contained low concentrations, with perfluorooctanesulfonic acid (PFOS) ranging from 0.99 to 1.5 ng/L. In contrast, waterways receiving runoff from EAFB contained elevated concentrations of multiple PFAS, including PFOS (up to 69 ng/L), perfluorohexanesulfonic acid (PFHxS; up to 54 ng/L), and perfluorooctanoic acid (PFOA; up to 18 ng/L). Spatial patterns were consistent with transport from historical AFFF source areas through connected drainage ditches and into downstream receiving waters, including the Little River. TOP assay results showed increases in several perfluoroalkyl acids following oxidation at the most contaminated site, indicating the presence of oxidizable precursor compounds. No measurable precursor contribution was observed at the reference or downstream sites. These results indicate that historical AFFF use at EAFB remains a likely source of PFAS contamination to surrounding waterways. Detection of oxidizable precursors suggests continued formation of terminal PFAS within the drainage network. This study provides baseline PFAS data for a previously uncharacterized watershed and supports the inclusion of precursor compounds in future monitoring efforts.

Disclaimer/Disclosure: This work was supported by the Arkansas State University Beck College of Sciences and Mathematics Seed Grant Program (Project: “Mapping PFAS Transport from Blytheville AFB Using GIS and Surface Water Monitoring,” awarded to S. Webb, May 2025)

4.02.P-Tu208 PFAS Toxicity Assessment in Marine Sediment: An Effects-Based Approach to Dredged Material Disposal Decisions

Morvarid Khazraee[1], Xiulan Wang[1], Peter Polivka[1], Kimbrie Gobbi[1], Jake Williams[2], Brad Helland[2], Mark Surette[1], Ron Malec[3] and William Hafner[3] (1)WSP USA Inc., (2)WSP USA, Inc., (3)Naval Facilities Engineering Systems Command, Northwest (NAVFAC NW)

Per- and polyfluoroalkyl substances (PFAS) are an emerging contaminant of potential environmental concern (COPEC) in sediment throughout the U.S. As part of a routine dredged material evaluation study, sediment from Sinclair Inlet, a Puget Sound embayment in Washington State adjacent to an industrial shipyard, was evaluated for open-water disposal suitability following the Washington State Dredged Material Management Program (DMMP) User Manual protocols. During Tier 1 evaluation, PFAS was identified as COPEC at the site, and the DMMP agencies subsequently requested that it be analyzed in sediment proposed for dredging. Results showed that PFAS were detected in the proposed dredged material (PFAS ranged from 0.1 to 0.93 ng/g dry weight). Interpretation of these detections for disposal decision-making is challenging because, although chemicals of concern were detected below established suitability criteria, no sediment quality benchmarks currently exist for PFAS in marine sediment. To address this regulatory gap, targeted toxicity bioassays were conducted to directly assess potential ecological effects associated with the PFAS-containing proposed dredged material.

A suite of toxicity bioassays was performed to provide effects-based context for the detected PFAS. Bioassays included a 10-day amphipod survival test, a 20-day juvenile polychaete test, and a 48-hour mussel larval development test. All tests were conducted according to standard protocols and met method control acceptance criteria.

No significant toxicity was observed in any bioassay. Amphipod survival, polychaete survival and growth, and mussel larval development in PFAS-containing sediment were statistically equivalent to PFAS-free reference sediments and control samples. These results indicate that PFAS at the detected concentrations were not associated with measurable sediment toxicity, and the proposed dredged material met biological criteria for open-water placement.
This study demonstrates the utility of bioassay-based approaches for interpreting PFAS detections in sediment when chemical benchmarks are unavailable. The absence of toxicity at measured PFAS concentrations indicates that the proposed dredged material poses negligible ecological risk and is appropriate for open-water disposal. These results highlight the importance of integrating direct biological testing with chemical characterization when evaluating the sediment containing contaminants for which no established criteria exist.

Advancing Risk-Based Decisions Through Exposure and Dosimetry Modeling

4.03.T-01 Leveraging PBK Modelling and Public Biomonitoring Data for Aggregate Exposure Assessment

Lara Lamon[1], Raphaëlle Lesage[1], Marjory Moreau[2], Stella Fragki[1], Leonie Lautz[1], Stephan Schaller[1] and Marco Siccardi[1] (1)ESQlabs GmbH, (2)ESQlabs LLC

Aggregate exposure (AE) — the combined exposure of an individual to a single chemical across multiple routes and pathways — is a cornerstone of next-generation risk assessment (NGRA). Yet, practical, transparent tools for conducting screening-level AE assessments using only publicly available data remain scarce. This work presents a physiologically based kinetic (PBK) modelling case study for di(2-ethylhexyl) phthalate (DEHP), a ubiquitous plasticiser and endocrine-active substance, to demonstrate how shared data resources can operationalise NGRA principles in a regulatory context.
A whole-body PBK model was developed in PK-Sim® to simulate the toxicokinetics of DEHP and its primary toxic metabolite MEHP in humans. Model confidence was established through two independent calibration scenarios: single oral administration (plasma and urine data) and repeated intravenous exposure in platelet donors (urinary MEHP data). A chronic aggregate exposure scenario was then constructed for an adult female, integrating literature-derived daily intake estimates from food ingestion (~0.30 mg/d) and inhalation (~0.55 mg/d), accounting for the 26% pulmonary deposition fraction of particle-phase DEHP. A population simulation was performed to characterise interindividual variability in internal exposure. Model predictions were compared against aggregated human biomonitoring (HBM) data for urinary MEHP retrieved from the IPCHEM platform (EU HBM Dashboard), covering 25 data points from multiple European cohorts.
The PBK model captured the distribution of the most exposed population subgroup, with 80% of the 95th-percentile HBM data points falling within the simulated population band. Conservative assumptions in the inhalation module drove an overestimation of median concentrations, consistent with the precautionary nature of a first-tier screening tool and identifying a clear priority for refinement. No individual-level external exposure data were required, demonstrating that aggregate HBM data alone can anchor a meaningful internal dose assessment.
This case study illustrates how PBK modelling and publicly accessible biomonitoring data can be effectively integrated at the screening level of an AE framework, providing a replicable methodological prototype for the internal dose assessment of environmental chemicals and advancing the practical application of NGRA

principles in chemical risk assessment.

Disclaimer/Disclosure: This work was supported by the Forschungszulage (Finanzamt Germany) under grant number 878/2025-3/4 (Project: Development of a novel, open, modular ecosystem for population-specific physiologically based pharmacokinetic and pharmacodynamic modeling)

4.03.T-02 Tiered Application of HTTK Methods to Large Chemical Inventories

John Wambaugh[1] (1)ULRI Chemical Insights

Biomonitoring provides direct measures of internal chemical concentration and captures aggregate exposure from multiple sources. However, these data alone do not define the relationships between external exposure and tissue concentrations. Addressing these gaps is critical for improving exposure assessment and informing risk-based public health decisions. Mathematical models can bridge these relationships, but they require information on chemical absorption, tissue partitioning, and clearance in biomonitoring matrices such as serum and urine.

Although thousands of chemicals are used in commerce and occur in the environment, experimental absorption, distribution, metabolism, and excretion (ADME) data are available for only a small subset. High-throughput toxicokinetics (HTTK) is a New Approach Method (NAM) that integrates generalized ADME models with chemical-specific parameters measured in vitro or predicted using quantitative structure–property relationship (QSPR) models. HTTK supports two major risk assessment applications: (1) in vitro–in vivo extrapolation (IVIVE), which translates in vitro bioactivity concentrations to estimated external doses, and (2) exposure reconstruction (ER), which links biomonitoring measurements to plausible intake rates.
In vitro HTTK methods have increased throughput while reducing costs and animal use, but experimental data generation remains resource intensive. QSPR models provide an alternative by predicting HTTK parameters computationally. However, these models are associated with a chemical applicability domain (AD) which defines the chemical properties for which predictions are expected to be reliable. For example, the approach of Roy et al. (2015) evaluates whether a chemical's scaled descriptors fall within the descriptor space of the training set.

Most ADME QSPR models have been developed for pharmaceuticals, with fewer models available for non-pharmaceutical chemicals, which often differ in structure and physicochemical properties. Here, we apply the HTTK QSPR methods of Dawson et al. (2021) to a large inventory of commercial chemicals, quantify the fraction falling outside model applicability domains, and generate ADME predictions for the remaining substances. These results support prospective exposure reconstruction from biomonitoring data for thousands of chemicals, enabling more comprehensive exposure assessment and risk-based decision making.

4.03.T-03 Combining New Approach Methods (NAMs) for Toxicity and Exposure for Next Generation Risk Assessment

Alessandro Sangion[1], Andy Nong[2], Tara Barton-Maclaren[2] and Jon Arnot[1] (1)Arnot Research & Consulting (ARC), (2)Health Canada

Humans and ecological receptors are exposed to thousands of chemicals, yet the relationships among external exposure, internal dose, and resulting biological effects remain poorly understood for most substances.

Environmental monitoring and biomonitoring data are available for only a small fraction of chemicals requiring assessment, and comprehensive measurement of all chemicals is not practical. In parallel, regulatory frameworks increasingly seek to reduce animal testing while maintaining protective risk assessments. Together, these challenges underscore the need for more efficient and predictive approaches to characterize chemical exposure and hazard. The Exposure And Safety Estimation (EAS-E) Suite is an integrated, freely accessible online platform that consolidates new approach methods (NAMs) for hazard and exposure data to support next generation risk assessment (NGRA) and chemical safety and sustainability. The platform combines curated chemical property databases with OECD-validated models for predicting chemical properties with quantitative in vitro-in vivo extrapolation (Q-IVIVE) models, and multimedia mass balance environmental fate and exposure models. These tools support reverse dosimetry applications linking external exposure estimates, biomonitoring data, and biologically relevant internal concentrations. In absence of chemical specific hazard data, the internal Threshold of Toxicological Concern (iTTC) can be used as a conservative default. This presentation provides case example applications including the calculation of bioactivity exposure ratios (BERs), linking in vitro bioactivity data to predicted in vivo exposure. The BER workflow incorporates an in vitro mass balance model to account for chemical disposition in assay systems and general physiologically-based kinetic models to estimate steady-state blood concentrations and administered equivalent doses for various species. Exposure estimates are generated using high-throughput production-to-exposure modeling that integrates near- and far-field pathways across chemical life cycles, enabling aggregate exposure assessment for humans and a range of representative ecological species. Exposure estimates are compared with available biomonitoring data. The methods support a “One Health” perspective by linking human and ecological exposure assessments and the practical implementation of NAMs for high-throughput risk-based evaluations for chemical priority-setting.

4.03.T-04 Biological Time Machines: Reducing Uncertainty in Metal Exposure and Risk Assessment Using Hair Analysis

Jennie Christensen[1] (1)TrichAnalytics Inc.

Population biomonitoring programs such as NHANES and the Canadian Health Measures Survey provide critical information on internal chemical concentrations but are typically limited to single time-point measurements that do not resolve how external exposures translate into internal dose over time. As a result, biomonitoring data are often under-utilized in environmental risk assessment, despite reflecting aggregate exposure from all sources. This presentation explores how hair analysis can complement existing biomonitoring and modeling frameworks by providing temporally resolved internal exposure information that supports exposure reconstruction and refined risk characterization. Hair is a keratinized tissue with high affinity for many metals, is metabolically inert once formed, and grows incrementally, preserving a chronological record of exposure. Using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS), individual hair strands can be analyzed at high spatial resolution, generating time-resolved concentration profiles for multiple elements concurrently from a single sample. These profiles integrate exposure across pathways and behaviors, capturing variability and episodic exposure that may be missed by blood or urine measurements.
Using mercury as an illustrative case, predicted risk was first assessed using conventional risk assessment approaches, where hazard quotients were calculated based on assumed exposure parameters such as dietary intake, exposure frequency, and average contaminant concentrations. These predicted estimates were then contrasted with actual exposure assessed using hair, which integrates internal dose over time. Hair-based exposure histories revealed substantial temporal variability in mercury uptake and demonstrated that estimated

hazard quotients did not always reflect biologically integrated exposure.
Hair-derived data can inform and constrain exposure models, support reverse dosimetry, and improve interpretation of population biomonitoring results by providing quantitative context on exposure timing, magnitude, and variability. By strengthening the linkage between external exposure, internal dose, and biologically relevant exposure dynamics, this approach supports Next Generation Risk Assessment frameworks and enhances the regulatory value of biomonitoring data for human and ecological risk assessment.

4.03.T-05 Diurnal and Seasonal Variation of Indoor-to-Outdoor Ozone Concentration Ratios Across Various Microenvironments in South Korea

Chahun Kim[1] and Kiyoung Lee[1] (1)Seoul National University

Ozone (O3) is a respiratory irritant with well-documented health effects. The indoor/outdoor (I/O) ratio of O3 concentration characterizes how effectively buildings attenuate outdoor O3 and is essential for accurate personal exposure assessment. However, systematic evidence across diverse microenvironments and temporal conditions remains limited. This study aimed to quantify the effects of season and time of day on hourly O3 I/O ratios across 13 microenvironments in South Korea. Hourly indoor O3 concentrations were measured across 13 microenvironments from December 2021 to February 2025 (N = 12,338). Season was classified as Hot (March–August) or Cold (September–February). Univariate associations were examined using Kruskal-Wallis tests and Spearman correlations. Separate linear mixed models with microenvironment-specific random intercepts and seasonal slopes were fitted for primary microenvironments (24-h monitoring) and other microenvironments (6-h monitoring), with cyclic time-of-day terms additionally included for primary microenvironments.
Results: The overall median O3 I/O ratio was 0.15 and varied significantly across microenvironments ($p < 0.001$). I/O ratios peaked in the early morning when outdoor O3 concentrations were lowest and reached their lowest values at midday, a pattern that remained significant in the linear mixed model after accounting for seasonal effects. Outdoor O3 concentration showed the strongest negative association with the I/O ratio. The hot season was associated with substantially lower I/O ratios than the cold season, with microenvironment-specific reductions ranging from 30.3% (Office) to 57.4% (School). Hourly O3 I/O ratios varied markedly by season, time of day, and microenvironment type. These findings provide microenvironment-specific, season-differentiated I/O ratios as empirical input parameters for more accurate indoor O3 exposure modeling.

Disclaimer/Disclosure: This research was supported by the Korea Environmental Industry & Technology Institute (KEITI) under Grant No. 2021003320002.

4.03.T-06 A Comparison Between Agent-Based and Integral Projection Modeling Approaches for Ecological Risk Assessment Over Short- and Long-Term Simulations

Nathan Pollesch[1], Chiara Accolla[2] and Maxime Vaugeois[3] (1)U.S. Environmental Protection Agency (US EPA), (2)Waterborne Environmental Inc., (3)Syngenta Ltd

Ecological risk assessment (ERA) faces challenges in extrapolating laboratory data to field populations. This study addresses these challenges by comparing the results of two different models developed for ERA when representing the same species and the same exposure scenario. The models are an integral projection model (IPM) and an agent-based model (ABM), both developed for the fathead minnow, a widely used standard test species for aquatic ERA in USA. The IPM is a size-structured model that uses readily measurable variables

(weight and length) to represent growth, survival, and reproduction (and their stress-driven changes) of fish in a population. The ABM is based on Dynamic Energy Budget theory and incorporates different modules to represent effects of stressors on the FHM metabolism. Both models incorporate seasonal reproduction, density-dependence, and time-variable chemical exposure scenarios, but they represent a few life-cycle processes differently. The ABM and IPM were independently developed and parameterized using existing literature and laboratory data on FHM life history.
Here we compare the effects of a simulated exposure on FHM populations over one-year and multiple-year simulations. For one-year simulations, the two models produced comparable results for the same ERA scenario, especially in the predicted percentage change of population abundance, biomass, and average size under exposure. In multi-year simulations, divergences can appear depending on how processes such as density dependence and reproduction are implemented.
By comparing the two models' outputs, we highlighted strengths and weaknesses of the two modeling approaches, as well as derived insights and recommendations for a practical and enhanced use of population models in ERA.

Advancing Risk-Based Decisions Through Exposure and Dosimetry Modeling

4.03.P-Th164 Application of an In Vitro Mass Balance Model for Predicting Measured Test Concentrations

Ke Xu[1], Sophie Emberley-Korkmaz[1], Florence Page-Lariviere[2], Rebecca Dalton[2] and Niladri Basu[1] (1)McGill University, (2)Environment and Climate Change Canada (ECCC)

Omics-, embryo-larval, and cell-based new approach methods (NAMs) are often carried out in microplates where analytical confirmation of test chemical concentrations is prohibitively expensive and often difficult. Researchers often rely on nominal exposure concentrations even though actual concentrations may differ substantially due to processes such as chemical adsorption to plastic walls and serum protein/lipid, volatilization, and precipitation. In this study, we evaluated the applicability of the IV-MBM EQP v2.1 mass balance model developed by Armitage et al. based on our use of the approach across multiple in vitro and embryo-larval exposure systems, including human intestinal epithelial cells (Caco-2), human liver cells (Hep G2), rainbow trout gill cells (RTgill-W1), rainbow trout embryos, and zebrafish embryos. The model uses the physicochemical properties of chemicals together with exposure system conditions to estimate the freely dissolved (i.e., bioavailable) concentrations in exposure media. A diverse set of chemicals spanning a range of physicochemical properties have been assessed to determine how chemical behavior is predicted to differ across exposure systems and biological matrices. Predicted concentrations were compared with nominal to evaluate the extent of concentration loss and bioavailability differences among models. Key factors, including water solubility, volatility, plastic adsorption, and organism composition significantly influenced modelled concentration estimates across systems. In the few cases where analytical measures were available, modelled concentrations are compared to evaluate the predictive performance and applicability of the model. Overall, these findings highlight the importance of accounting for chemical partitioning and exposure conditions to improve exposure characterization and interpretation of in vitro and embryo toxicity data, and provide some insights based on our use of the IVMBM-v2 model.

4.03.P-Th165 Mollusc-Based Biodosimetry and Biomonitoring for Environmental Radiation Assessment

Lauren Song[1] and Denina Simmons[1] (1)Ontario Tech University

Growing global energy demand and the shift to low carbon power sources are increasing interest in nuclear energy, including the use of Small Modular Reactors (SMRs). As these technologies expand, environmental radiation monitoring must improve to support risk based decisions and protect nearby ecosystems. Human health effects of ionizing radiation are well explored, but ecological impacts remain less understood, especially in freshwater environments near nuclear facilities. This project addresses the need for reliable, retrospective methods to assess environmental radiation exposure. We will examine mollusc shells as biodosimeters since they are widespread in both terrestrial and aquatic environments, do not migrate far distances, and incorporate stable radiation induced signals into their carbonate structures. Common Canadian freshwater mussel species offer accessible and locally relevant options for environmental monitoring. Emerging evidence shows that mollusc shells retain paramagnetic signatures that correlate with absorbed dose, indicating their potential as environmental indicators. Electron Paramagnetic Resonance (EPR) detects free radicals formed in shells after exposure to ionizing radiation. This presentation will synthesize current research on shell based biodosimetry, identify factors that influence dose reconstruction, and evaluate conditions that affect signal stability and measurement reliability. Our goal is to advance exposure and dosimetry modeling by assessing carbonate shells as a biological material that can complement existing monitoring systems. Integrating mollusc based biodosimetry into environmental assessment frameworks can strengthen ecological risk evaluation and support informed decision making as nuclear energy infrastructure evolves.

Behavior and Fate of Legacy and Emerging Contaminants in Changing Arctic and Antarctic Environments

4.04.T.A-01 Chemical Characterization and Contamination Assessment in Surface Coastal Sediments of Canadian Arctic Communities

Camille Brice[1], Jean-Carlos Montero-Serrano[2], Richard St-Louis[3] and Maikel Rosabal[4] (1)Institut National de la Recherche Scientifique (INRS), (2)Institut des Sciences de la Mer, Université du Québec à Rimouski (ISMER-UQAR), (3)Université du Québec à Rimouski (UQAR), (4)University of Quebec in Montreal (UQAM)

The chemical composition of coastal sediments near six Canadian Arctic communities was investigated to evaluate metal distribution and potential contamination. Surface sediment samples were collected from Inuit communities in Nunavut and the Inuvialuit Region during the summers of 2022 and 2023 and analyzed for grain size, as well as major and trace element concentrations. Total metal concentrations were determined using energy-dispersive X-ray fluorescence, while selected samples underwent partial acid digestion followed by mass spectrometry to quantify acid-extractable fractions. Results from Tuktoyaktuk, Resolute Bay, Grise Fiord, and Qikiqtarjuaq show metal levels consistent with natural backgrounds. However, occasional adverse biological effects on aquatic fauna are expected to occur in Tuktoyaktuk due to elevated inputs from the Mackenzie River. Sediments from Pond Inlet present variable elemental compositions reflecting local lithology and potential localized anthropogenic sources. Near Kugluktuk, sediments contain elevated total concentrations of V (50–1160 μg/g) and Cr (100–1700 μg/g), likely derived from both natural and local anthropogenic sources. Natural sources include eroded material from ultramafic intrusions carried by the Coppermine River, whereas

municipal landfills and sewage located close to the coast appear to be significant sources of pollution. Despite high total concentrations, acid-extractable fractions are significantly lower (Cr < 180 μg/g; V < 640 μg/g), suggesting that the metals are predominantly bound to detrital minerals, limiting their mobility and bioavailability. Overall, this study highlights the importance of distinguishing total from bioavailable metal concentrations and understanding sediment dynamics to better support Arctic communities in coastal management and protection of country food resources.

4.04.T.A-02 Long-Term Trends of Hexachlorocyclohexanes in the Western Arctic Ocean

Terry F. Bidleman[1], Liisa M. Jantunen[2] and Mats Tysklind[1] (1)Umeå University, (2)Environment & Climate Change Canada

Technical hexachlorocyclohexane (HCH), used worldwide since the 1940s, consists mainly of four isomers, α-HCH, β-HCH, γ-HCH and δ-HCH. Only γ-HCH (a.k.a. lindane) has insecticidal properties. Worldwide use of technical HCH peaked in the 1970s-early into the1980s, then global emissions declined strongly. Lindane use continued in diminishing quantities for another two decades and by 2009 α-HCH, β-HCH and γ-HCH had been added to the Stockholm Convention.

HCHs have been measured for nearly four decades in the Bering-Chukchi seas (B-C), Canadian Archipelago, Beaufort Sea and Canada Basin (hereafter the "Western Arctic Ocean", WAO). Data were compiled for an upcoming assessment of contaminant temporal trends by the Arctic Monitoring and Assessment Program (AMAP). From 1979-2017, over 350 measurements in surface seawater (0-20 m) had been published for α-HCH, the most abundant isomer in technical HCH, and less frequently for the other isomers. Plots were made of log concentration (ng/L) versus year (Log C = m*year + b). Times for 50% reduction (t0.5, y) were calculated as log 2/(m) = 0.301/m, with 95% confidence limits.

Concentrations of all HCH isomers in the WAO decreased over time (negative t0.5). Most rapidly declining was α-HCH, with central (95% limits) t0.5 of -7.2 (-8.0 to -6.6) y ($p < 1.0E-64$). Next in order was γ-HCH, t0.5 -16.6 (-20.6 to -13.9) y ($p < 1.0E-20$). The slowest decline, with lowest significance, was for β-HCH, t0.5 -21.8 (-41.1 to -14.1) y ($p < 5.0E-4$). Proportions of the HCH isomers were expressed as the fractions FAG = α-HCH/(α-HCH + γ-HCH) and FAB = α-HCH/(α-HCH + β-HCH). The significant ($p < 1.0E-6$) downward trends of FAG and FAB versus year reflect preferential decrease in α-HCH relative to β-HCH and γ-HCH, or an increase in the latter two isomers.

Changing isomer proportions reflect replacement of technical HCH by lindane (>99% γ-HCH) and the chemical/biological stability of the different isomers. Emission profiles of α-HCH and β-HCH were similar, but β-HCH is mainly transported by ocean currents and its delivery to the WAO lagged behind α-HCH, which came largely from atmospheric transport (Yang et al., Environ. Sci. Ecotechnol., 2023). The greater stability of β-HCH and its lower potential for revolatilization may also play a role (Hao et al., Arch. Environ. Contam. Toxicol. 2026). Trends and proportions of HCH isomers in seawater provide a basis for interpreting their bioaccumulation and biomagnification.

Disclaimer/Disclosure: Research at Umeå University is supported by the Swedish marine strategic research

environment EcoChange (https://www.umu.se/en/ecochange/), Swedish Research Council Formas.

4.04.T.A-03 Local Sources vs Long-Range Transport: Cyclic Volatile Methylsiloxanes in Antarctica and the Arctic

Debra McNett[1], Jeremy Durham[2], Maja Nipen[3], Rita Seston[4], Timothy Barber[5], Oda Siebke loge[3], Vladimir Nikiforov[6], Kathleen Plotzke[2], Mark Irvine[7], Isabel Sauermilch[7], Robert Bialik[8], Katarzyna Fudala[9], Dragomir Mateev[10], Evgen Dykyi[11] and Shihe Xu[12] (1)EHSNett Consulting, (2)Dow Chemical Company, (3)NILU, (4)Hyla Environmental Consulting LLC, (5)Environmental Resource Management (ERM), (6)Norwegian Institute for Air Research (NILU), (7)ERM, (8)Institue of Biochemistry and BioPhysics Polish Academy of Sciences, (9)Institute of Biochemistry and Biophysics Polish Academy of Sciences, (10)Bulgaria Antarctic Institute, (11)State Institution National Antarctic Scientific Center, Ukraine, (12)Tridge Consulting

Cyclic volatile methylsiloxanes (cVMS) are high-production-volume chemicals used globally in personal care products and industrial applications. Their occurrence in remote environments raises questions about long-range atmospheric transport and local emissions. We present results from two studies investigating the cVMS D4, D5 and D6 in polar regions: Antarctica (2023/24) and Arctic Svalbard (2023). Comparable sampling and analytical methods were applied for air, terrestrial, and aquatic matrices to enable comparison between sites and hemispheres.

Across all Antarctic stations, D4, D5, and D6 concentrations in outdoor air were generally very low, with detectable levels primarily restricted to research-station settlements and absent or near detection limits in more remote areas. Extended winter deployments at the Norwegian Troll station revealed extremely low background concentrations, confirming minimal long-range inputs. In contrast, targeted sampling near wastewater outlets at the Bulgarian Antarctic research station showed clear evidence of local contamination in sediments, demonstrating the relevance of point sources in remote regions. Terrestrial matrices (moss, lichen, soil) showed almost exclusively non-detects, while krill showed exclusively non-detects.

In Svalbard, D4, D5 and D6 concentrations were higher than Antarctica, reflecting a combination of long-range or regional transport and local human activity. Air concentrations at the settlement of Ny-Ålesund exceeded those at Antarctic stations by two to three orders of magnitude, while a remote Arctic location (Zeppelin Observatory) showed low but detectable background levels. No or extremely low levels of the studied cVMS were detected in Arctic terrestrial and aquatic media, aligning with the Antarctic findings and supporting negligible accumulation in these matrices.

Together, these polar datasets provide the most geographically extensive assessment of D4, D5 and D6 in remote environments to date. The results highlight (i) the dominance of local emissions in shaping near-field concentrations at research stations, (ii) very low to undetectable levels in terrestrial and aquatic compartments, and (iii) clear hemispheric differences in atmospheric burdens. These findings contribute to ongoing regulatory discussions by demonstrating the extremely low environmental presence of the studied cVMS in pristine regions and the importance of distinguishing true background levels from isolated point sources.

Disclaimer/Disclosure: The studies have been funded by Silicones Europe (part of CEFIC) and the Norwegian Environment Agency.

4.04.T.A-04 Increasing Concentrations of Hexachlorobenzene and Other Organochlorine Byproducts in Fish in the Canadian Arctic

Derek Muir[1], Jane Kirk[2], Mary Gamberg[3], Marlene Evans[2], Feiyue Wang[4], Gary Stern[4], Gerald Tetreault[5], John Chételat[5], Benjamin Barst[6], Günter Köck[7], Debbie Iqaluk[8] and Simon Wilson[9] (1)University of Guelph, (2)Environment and Climate Change Canada (ECCC), (3)Gamberg Consulting, (4)University of Manitoba, (5)Environment & Climate Change Canada, (6)University of Calgary, (7)Institute for Interdisciplinary Mountain Research, (8)Resolute Bay, (9)Arctic Monitoring and Assessment Programme

There is emerging evidence for increasing concentrations of hexachlorobenzene (HCB), pentachlorobenzene (PeCB), and hexachlorobutadiene (HCBD) in air at Alert in the Canadian High Arctic. Global air monitoring using passive sampling has also shown increasing HCB, PeCBz, and HCBD at multiple northern locations, including in sites in Svalbard, Iceland, and the Yukon. In the case of HCB, these increases come after decades of declining air concentrations related to bans on use as a fungicide and reduction in its presence as an impurity in some pesticides . Less is known about trends and sources of another byproduct, octachlorostyrene (OCS); atmospheric concentrations in the Great Lakes were unchanged over the period 1991 to 2020. An assessment of time trends in Arctic biota from the 1990s to 2014 found that HCB and PeCB were declining slowly (mean change 2.6 and 3.8%/yr, respectively). In this study we compared the long-term trends of HCB, PeCBz, HCBD and OCS fish from 7 lakes in the Canadian Arctic. We hypothesized that increasing air concentrations of these compounds will be reflected in trends in fish as a result of long-range transport, deposition, and bioaccumulation. Concentrations (ng/g lipid weight), based on samples from the 1990s to 2024, were available from long term monitoring projects for lake trout (Salvelinus namaycush), burbot (Lota lota) and Arctic char (Salvelinus alpinus). Temporal trends were analysed using HARSAT, an open-source, R-based statistical package. Increasing concentrations of HCB, HCBD and OCS were found for the majority of the 10 available datasets. Trends for PeCB differed, with significant declines in 3 datasets and no change in 6 others. The increasing trends for HCB and OCS were most evident for the years between 2005 to 2023, while concentrations from the 1990s to mid-2000s generally showed a decline. The most rapid increase was for HCBD in Arctic char, and in burbot and lake trout from Great Slave Lake, which began in the early 2000s and reached a maximum in 2023. HCB and OCS showed similar trends at all sampling locations despite vast differences in lake size and population densities. The increase in HCBD in char, burbot and lake trout mirrored atmospheric measurements at Alert from 2010 to 2021. While the trends of all 4 byproducts are probably best explained by primary sources, the rapidly warming Arctic climate could be driving secondary emissions of these semi-volatile compounds.

Disclaimer/Disclosure: The long term trend monitoring was funded by Canada's Northern Contaminants Program

4.04.T.A-05 Diverging Food Web Structure and Mercury Dynamics in Paired High Arctic Lakes Affected by Climate Change

Margo Leggatt[1], Jane Kirk[2], Gerald Tetreault[2], Derek Muir[3], John Chételat[4], Timothy Jardine[5], Ariane Cantin[1], Jason Miller[4], Debbie Iqaluk[6], Melissa Lafrenière[7], Carl Mitchell[8] and Benjamin Barst[1] (1)University of Calgary, (2)Environment and Climate Change Canada (ECCC), (3)No Affiliation, (4)Environment Climate Change Canada, (5)University of Saskatchewan, (6)Hamlet of Resolute Bay, (7)Queens University, (8)University of Toronto

Rapid warming in the Arctic is leading to substantial changes to High Arctic lakes. Permafrost thaw in lake catchments can increase nutrient and sediment runoff, and alter water chemistry and lake productivity, which may in turn reshape aquatic food web structure. Permafrost stores considerable amounts of mercury (Hg), that is vulnerable to release during thaw. Consequently, changes in lakes and their catchments have implications for Hg inputs, bioaccumulation, and trophic transfer in lake food webs that support Arctic char (Salvelinus alpinus), a top predator in many High Arctic lakes and an ecologically and culturally important species. East and West Lakes at Cape Bounty on Melville Island, Nunavut (Canada) provide a unique study site to identify the effects of climate change on lake food web structure and Hg dynamics. These similarly sized, adjacent lakes with distinct catchments have been closely monitored since the early 2000s and have isolated populations of Arctic char. One of the warmest summers at Cape Bounty was recorded in 2007, which led to deepening of the active layer and increased thermokarst activity. Permafrost degradation was more severe in the West Lake catchment and a series of underwater mass movement events occurred within the lake itself. These mass movement events led to a sustained increase in turbidity and a 7%/year increase in char Hg concentrations, while East Lake char Hg decreased over a similar period. Although differences in char Hg could be driven by increased delivery of Hg to West Lake, alterations to the lake food webs may also play a role. Over a decade of carbon and nitrogen stable isotope ratios measured in Arctic char coupled with recent data of the remaining food web components, suggest dietary divergence between the East and West Lake Arctic char populations. West Lake Arctic char appear to have shifted from consuming chironomids to diets predominately composed of mysids since 2008 (when char sampling began and the onset of high turbidity). A shift in West Lake char diets is reflected in increasing mean carbon stable isotope values (-26.5‰ in 2009, -22.5‰ in 2025), a larger corrected standard ellipse area relative to East Lake char (4.63‰^2 vs. 1.59‰^2), and is supported by a retrospective char stomach content analysis. Although climate change is expected to impact food web structure and Hg pathways, evidence of these changes is limited, making East and West Lakes an important comparative study system.

4.04.T.A-06 From Glacier to Coast: Mercury Concentrations in Water and Sediment Across a Gradient of Glacial Influence

Tamara Rivera[1], Kristin Nielsen[1], Benjamin Barst[2], Sarah Janssen[3], Jordan Jenckes[4] and Isabelle Nelson[1] (1)University of Texas Austin, (2)University of Calgary, (3)U.S. Geological Survey (USGS), (4)University of Alaska Anchorage, Department of Computer Science and Engineering, Anchorage, AK

Alaska, USA currently contains ~12% of the total global glacierized area and is warming at nearly twice the global average, leading to rapid retreat of glaciers and ice sheets. A small number of previous studies have shown that glacial meltwater mobilizes previously sequestered inorganic mercury to downstream wetland and coastal environments; however, the degree to which glacially-derived inorganic mercury is microbially converted to bioavailable organic methylmercury in these rapidly evolving ecosystems has yet to be explored. Methylmercury bioaccumulates and biomagnifies in food webs and may pose serious risks to wildlife and

human health if concentrations are high enough; thus, studies examining glacial mercury export and bioavailability in coastal environments are urgently needed. To investigate these processes, we quantitatively evaluated total mercury and methylmercury concentrations in various environmental matrices and calculated mercury yields from three watersheds spanning a gradient of glacial influence (0-62%) in Kachemak Bay, AK. Watershed characteristics and water quality data were also evaluated to identify key determinants of Hg fate and partitioning behavior. Results indicate that mercury yields increase with glacial influence and are comparable to some of the highest annual Hg yields reported in literature to date. Interestingly, sediment mercury dynamics were more complex: methylmercury concentrations show a strong positive relationship with organic matter content and increase with terrestrial influence, whereas sediment total mercury concentrations did not differ significantly among sites. In aqueous samples, mercury appeared to be conservatively transported from glacial rivers to downstream environments, where conditions may be conducive to mercury methylation. Together, these findings highlight the important role of glacial melt in mercury transport and transformation and underscore the need to better understand how continued glacier retreat may influence mercury fate and bioavailability in coastal ecosystems.

Behavior and Fate of Legacy and Emerging Contaminants in Changing Arctic and Antarctic Environments

4.04.T.B-01 Cross-Ecosystem Transfer of Methylmercury in High Arctic Riparian Food Webs: Evidence for Aquatic and Terrestrial Pathways

Camryn Middlebrooks[1], Matt Chumchal[1], Kurt Burnham[2], Benjamin Strang[1], Aleah Appel[1], Sommerlyn Babineau[1], Ethan Cary[1], Titus Crawford[1], Sage Dale[2], Charlie Duethman[1], Aidan Duffield[1], Piper Dumont[2], Skylar Dunn[1], Sydney Hill[1], Ramsey Jennings[1], Ben Katzenmeyer[1], Chidi Mbagwu[1], David Peebles[1], Emma Sullivan[1], Tyler Williams[1], Lance Viscioni-Wilson[1], David Wright[1], Kimberlee Whitmore[1], Denice Rodriguez[1], Kyle Trevor[1] and Tristan Williams[1] (1)Texas Christian University, (2)High Arctic Institute

Rapid environmental change in the Arctic has the potential to alter mercury cycling and shape methylmercury (MeHg) transport across connected freshwater and terrestrial food webs. Freshwater ecosystems are important sources of MeHg, a potent neurotoxin, to terrestrial consumers, yet the degree to which this subsidy elevates Hg concentrations in terrestrial predators remains unclear in High Arctic landscapes. We quantified Hg concentrations in aquatic insects, terrestrial insects, and spiders across six freshwater ponds in High Arctic Greenland to evaluate cross-ecosystem transfer of MeHg and the roles of trophic position and distance from aquatic habitats in structuring exposure. Aquatic and terrestrial insects were collected from ponds and adjacent shorelines, while spiders were collected at 0 m, 10 m, and 35 m from pond shorelines. Across all ponds, spiders consistently exhibited the highest MeHg concentrations. Spider Hg concentrations declined significantly with distance from ponds, with individuals collected 35 m from shorelines exhibiting lower Hg concentrations than those collected at 0 m and 10 m, indicating that freshwater-derived Hg subsidies weaken with increasing distance from aquatic habitats. Contrary to expectations that terrestrial insects would exhibit lower Hg concentrations than aquatic taxa, aquatic and terrestrial insects did not differ in overall MeHg concentrations. Instead, Hg exposure within terrestrial insects was strongly structured by feeding guild, with terrestrial detritivores and predators being significantly contaminated. Elevated MeHg concentrations in terrestrial detritivores suggest that contamination may also be entering terrestrial food webs through detrital pathways, indicating that Hg transfer may not exclusively be driven by aquatic subsidies.

These results suggest that trophic position is a major determinant of Hg exposure in this High Arctic food web and demonstrate that freshwater-derived contaminants are transferred into adjacent terrestrial communities. Elevated MeHg concentrations across terrestrial feeding guilds indicate multiple pathways of contaminant transfer and suggest that terrestrial detrital pathways may represent an additional source of Hg exposure beyond aquatic subsidies.

4.04.T.B-02 Characterization of the Sensitivity of Epontic Communities (Ice Algae and Copepods) in the Arctic Ocean to Copper, Nickel, and Zinc

Amandine Greil[1], Léna Guimard[1], Karima Hadria Gondry[1], Dylan Beard[2], Fleur Issac[2], Tamzin Blewett[2], Claude Fortin[3] and Anne Cremazy[3] (1)Institut National de la Recherche Scientifique, (2)University of Alberta, (3)National Institute for Scientific Research (INRS)

The development of new low-carbon technologies is a priority for many countries, including Canada. However, this development is accompanied by increased demand for certain metals and, consequently, increased mining activity. These operations can lead to higher concentrations of metals in surrounding aquatic environments and thus pose a risk to the organisms living there. In the Canadian Arctic, where mining activities may intensify in the future, the ecological impacts remain difficult to assess because ecotoxicological data for Arctic species are limited. The effects on planktonic communities, which form the base of the food web, could affect the entire ecosystem. This project aims to study the effects of three metals from Canada's strategic mineral list (copper, nickel, and zinc) on a natural community of Arctic ice algae and copepods collected in the field. In May 2025, ice algae and copepods were sampled near to Cambridge Bay about 10 km from the Canadian High Arctic Research Station (CHARS) using ice corers and a plankton net. Toxicity tests were then conducted at CHARS in a cold room for 11 days (algae) and 16 days (copepods). Copper and zinc reduced algal biomass from 40 µg/L and 1400 µg/L, respectively (effects on chlorophyll-a), but not nickel within the tested range (up to 3000 µg/L). Toxicity thresholds for copper and zinc were similar to those reported for temperate algae, while temperate species appear more sensitive to nickel (growth inhibition around 1500 µg/L). Effects on photosynthetic performance were less pronounced than those on biomass, suggesting that toxicity mechanisms other than impaired photosynthesis are involved. Copper and zinc caused mortality in copepods at concentrations as low as 20 µg/L and 2000 µg/L, respectively, whereas nickel did not induce mortality even at the highest concentration tested (3200 µg/L). The 50% lethal concentration (LC50) for copper was comparable to values reported for temperate copepods, while zinc was less toxic to Arctic copepods (LC50 = 2200 µg/L) than to temperate species (LC50 = 700 µg/L). In contrast, temperate copepods appear considerably more sensitive to nickel, with reported LC50 values around 100 µg/L. The effect concentrations observed for algae and copepods were higher than those naturally found in the Arctic Ocean. However, in some contaminated areas, copper and zinc concentrations reached 35 and 720 µg/L, respectively, potentially posing a risk to epontic communities.

4.04.T.B-03 Landfill- and Wastewater-Influenced Spatial Distribution of PFAS in Arctic Surface Waters Near Baker Lake, Nunavut

Tianqi Jia[1], Shira Joudan[1] and Mark Hanson[2] (1)University of Alberta, (2)University of Manitoba

Per- and polyfluoroalkyl substances (PFAS) were investigated in surface waters surrounding Baker Lake, Nunavut, to assess PFAS variability near landfill- and wastewater-influenced areas. Samples were collected

from six subregions in 2024 and 2025, including a landfill-influenced wetland, the wastewater pathway to Airplane Lake, the outflow to Baker Lake, Baker Lake nearshore, and peripheral sites to the west/southwest and east/northeast. Across 30 samples, Σ41PFAS concentrations ranged from 3.63 to 55.6 ng/L and showed spatial heterogeneity with little interannual variation. Baker Lake samples were below the proposed Canadian PFAS drinking water limit (30 ng/L). The highest concentrations occurred in the landfill-influenced wetland, whereas peripheral sites showed lower concentrations. Sites along the wastewater pathway and the outflow to Baker Lake exhibited intermediate concentrations, suggesting downstream transport from the wetland. PFAS composition varied among subregions. The landfill-influenced wetland was enriched in perfluoroalkane sulfonic acids (PFSAs) and perfluoroalkyl carboxylic acids (PFCAs) with perfluoroalkyl carbon chains ≥ C6, whereas Baker Lake nearshore and peripheral east/northeast sites were increasingly dominated by short-chain PFCAs. Peripheral west/southwest sites showed higher telomer acid contributions. These results suggest that PFAS variability in the Baker Lake system is controlled primarily by localized wastewater and landfill influences, followed by downstream transport and dilution along hydrologically connected waters. This study highlights how local infrastructure shapes PFAS heterogeneity in a low-background northern environment.

4.04.T.B-04 Long-Term Trends in Accumulation of Legacy Polychlorinated Biphenyls in Ringed Seal in Relation to Shifting Feeding Ecology at High and Low Arctic Canadian Sites

Bailey Levesque[1], Magali Houde[2], Nadia Facciola[3], Derek Muir[4], Steven Ferguson[5] and Melissa McKinney[1]
(1)McGill University, (2)Environment and Climate Change Canada (ECCC), (3)Environment and Climate Change Canada, (4)No Affiliation, (5)Fisheries and Oceans Canada

Environmental transport and resistance to degradation have resulted in the well-documented accumulation of persistent organic pollutants, such as polychlorinated biphenyls (PCBs) in Arctic marine biota. These species are also currently experiencing rapid habitat and food web alterations due to climate change. Changing trophic relationships may lead to altered contaminant exposures, yet knowledge gaps exist on how trophic shifts may impact contaminant accumulation in biota. The ringed seal (Pusa hispida) is a high-trophic level species harvested and consumed by Canadian Arctic Inuit communities. In this study, we aimed to evaluate long-term temporal trends in ringed seal feeding ecology and subsequent influences of dietary changes on the direction and magnitude of available contaminant time trends. Ringed seal tissue samples were collected by Inuit collaborators during harvests over three decades (1992-2023) at two Canadian Arctic sites: Resolute Bay in the central Canadian Archipelago (74.6973°N) and Arviat in Western Hudson Bay (61.1078°N). Fatty acids were extracted from blubber samples (n = 311) and analyzed using a GC-FID to determine fatty acid composition. As dietary fatty acids are transferred from prey to predator in predictable patterns, this was used to assess changes in seal feeding ecology. Concentrations of PCBs were measured in blubber (n = 390) through analysis at accredited laboratories. Site-specific changes were observed with significant changes seen in the annual mean proportion of dietary fatty acids 16:2n4, 16:4n1, 18:3n6, and 18:4n3 in Arviat and 20:4n6 and 21:5n3 in Resolute Bay. Both locations also saw declines in the annual mean proportion 20:1n7, 20:1n9, 22:1n11, and 20:5n3 which are consistent with reductions in ice-associated prey and sea ice primary productivity. Decreasing trends were also seen in ΣPCB concentrations at both sites with annual decreases of 7% and 1.8% seen in Arviat and Resolute ringed seals, respectively. Potential correlations between the observed dietary changes and contaminant trends are currently being investigated. These results will support the Arctic Monitoring and Assessment Programme and effectiveness evaluations conducted under the UN Stockholm and Minamata

Conventions. Through the sharing of results with federal and regional health agencies, this study will contribute to the informed consumption of traditional food sources by northerners.

4.04.T.B-05 Legacy Polychlorinated Biphenyls and Organochlorine Pesticides in Eastern Canadian Arctic Resident and Range-Shifting Toothed Whales

Ambar Maldonado Rodriguez[1], Steven Ferguson[2], Nigel Hussey[3], Victorine Lambert[1], Cory Matthews[2], Cortney Watt[2] and Melissa McKinney[1] (1)McGill University, (2)Department of Fisheries and Oceans Canada, (3)University of Windsor

Many legacy persistent organic pollutants (POPs), such as polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCPs), remain a threat to marine mammals decades after international bans and regulations. Throughout the Arctic, climate change may be altering wildlife exposure to such contaminants through remobilization from ice reservoirs and biotransport via northward range shifts of marine species. As upper trophic level consumers, toothed whales face increasing anthropogenic pressures in Arctic regions and are indicators of contaminant exposure throughout their marine food webs. Thus, the continued monitoring of legacy POPs in both well- and poorly-studied toothed whale species is essential. Here, we quantify PCB and OCP concentrations in the blubber of Arctic resident and range-shifting sub-Arctic toothed whales using a QuEChERS extraction protocol and assess the variables influencing inter-specific differences in contaminant loads. Sampling (n = 81) took place across Baffin Bay in the Eastern Canadian Arctic and included Arctic belugas (Delphinapterus leucas) and narwhals (Monodon monoceros), and sub-Arctic sperm whales (Physeter macrocephalus), northern bottlenose whales (Hyperoodon ampullatus), and killer whales (Orcinus orca). There were higher sum PCB concentrations in sperm whales (mean +/- SE = 3.92 +/- 0.77 mg/kg lipid weight (lw)) than in belugas (1.72 +/- 0.19 mg/kg lw) and narwhals (1.37 +/- 0.68 mg/kg lw). Of the OCPs, dichlorodiphenyltrichloroethanes (sum DDTs) were more abundant in sperm whales (4.02 +/- 1.0 mg/kg lw) than in belugas (1.03 +/- 0.12 mg/kg lw) and narwhals (0.99 +/- 0.52 mg/kg lw). In contrast, chlordane-related compounds (sum CHLs) were similar across these three species, but slightly higher for belugas (1.66 +/- 0.24 mg/kg lw) and narwhals (1.51 +/- 0.82 mg/kg lw) than sperm whales (1.40 +/- 0.28 mg/kg lw). Ongoing analysis of killer whale and northern bottlenose whale samples will elucidate differences in legacy POP trends among Arctic resident and range-shifting toothed whales in the Eastern Canadian Arctic. These findings will further support long-term contaminant monitoring and assessments of ecosystem health in this vulnerable Arctic region.

4.04.T.B-06 Contaminants Have Wings. Snow Goose Feathers As Proxies of Anthropogenic Impact

Marie Le bagousse[1], Pierre Legagneux[2], Sarah Berubé[3], Dominique Fauteux[4] and Julien Gigault[1] (1)Takuvik, Université Laval, (2)Université Laval, (3)INRS, (4)Arctic Centre, Canadian Museum of Nature

Global production of material is constantly increasing in the world. This production and use are the source of Anthropics contaminants releases into the environment. In present, new emerging contaminant such as plastics and metals are found in all ecosystems including Arctic
However it remains unresolved since when thse contaminants are present in arctic and their potential interaction with biodiversity. It is therefore crucial to study the evolution of these contaminants in relation to Arctic biodiversity over time, particularly through so-called sentinel species. From all natural sentinels for

contamination, birds are recognized as one of the best indicators of environmental biomonitoring. Their level of contamination varies greatly depending on their diet and the geographical areas they occupy. In this study, we propose a new approach based on the feathers and some contaminant tracing: Nanoplastics and traces metals. The feather, a non-destructive matrice, are considered as a natural passive sampling device for contamination. In our project we focused more specifically on the Greater Snow Goose, a migratory species that lives between the United States (winter) and the high Arctic (summer). Thanks to our feathers collected from the field (Bylot Island – Nunavut, Goose Island – Quebec, Canada) and museum archives dating from the early 1900s up to the present day, we analysed nanoplastics and trace metals presence after prior analytical development for specific extraction and identification. Our preliminary results on metals show a decrease in several metals, such as Cadmium since 1960s.
In contrast, our preliminary results on plastics show a trend that vary over time in the concentration of plastics such as polypropylene. Polypropylene was detected in the 1960s on feather, but then became undetectable until the 2010s. These differents trends may be linked to anthropogenic emissions from industry and the implementation of regulations, for example.

Behavior and Fate of Legacy and Emerging Contaminants in Changing Arctic and Antarctic Environments

4.04.P-Th086 Introducing the Updated OECD Pov and LRTP Screening Tool: Overview and Application for Recently Regulated POPs

Michael Beking[1], Knut Breivik[2], Andreas Buser[3], Jon Arnot[4], Liisa Toose[4], Mark Bonnell[1], Asako Hotta[5], Matthew MacLeod[6] and Martin Scheringer[7] (1)Environment and Climate Change Canada, (2)NILU / University of Oslo Norway, (3)Federal Office for the Environment (FOEN), (4)Arnot Research & Consulting (ARC), (5)Organisation for Economic Co-operation and Development (OECD), (6)Stockholm University, (7)RECETOX Switzerland

The OECD Pov and LRTP Screening Tool (The Tool) is a consensus-based multimedia fate model, developed by an OECD expert group about 20 years ago, to assess the long-range environmental transport potential (LRTP) and overall persistence (Pov) of organic chemicals in the environment. The Tool (Version 2.2), released in 2008, has found widespread use in variable regulatory contexts, including under the Stockholm Convention (SC) on Persistent Organic Pollutants (POPs) for which it has been applied for Screening (Annex D) and in the Risk profile (Annex E) for 15 POPs. In 2023, the OECD published a thorough review of the Tool and commenced a project to implement several recommended updates. Here, we introduce an updated version of The Tool (Version 3.0) which features an updated parameterization of wet deposition and allows for consideration of transfer and accumulation of chemicals in a remote region following combined transport by air and water. In particular, The Tool can now also calculate a new set of LRTP metrics corresponding to the emissions fractions approach, one benefit of which is more explicit modelling of the potential for accumulation in remote environments. In addition to these scientific improvements, software updates include improved result exporting, easier interface navigation, and a revised technical instruction manual. As part of developing scientific guidance on its use, we exemplify the utility of the model by applying it to 20 neutral POPs that have been regulated under the SC since the previous version of The Tool was released. The updated version of The Tool increases its benefit to the scientific community, chemical industries, and regulatory agencies that are interested in LRTP assessments of organic chemicals in the context of the SC and beyond.

4.04.P-Th087 Halomethoxybenzenes As Tracers of Land-Sea-Air Exchange in the Northern Baltic

Terry Bidleman[1], Kathleen Agosta[1], Andersson Agnata[1], Brugel Sonia[1], Ericson Lars[1], Olle Nygren[2], Tysklind Mats[1] and Linda Zetterholm[1] (1)Umeå University, (2)Damina AB

Many chlorinated fungal metabolites (CFMs) are produced during decomposition of forest litter, e.g. Drosophilin A (DA) and its methyl ether, DAME. Related compounds include brominated anisoles (BAs) from marine and anthropogenic sources. We are using these halomethoxybenzenes (HMBs) as model terrestrial- and marine-derived compounds to follow land-sea-air transfer processes in the subArctic northern Baltic Sea. Here we report HMBs in forest soil/litter (S/L), river and estuarine water, and their air-surface exchange.

Soil/litter (S/L) was collected in Västerbotten County (VC) forests, water samples from VC rivers and Baltic estuaries, and air samples from Sweden and Arctic Finland. Sampling and analytical methods are reported (Bidleman et al., 2023. Front Mar. Sci. 10, 1161065). Air-surface exchange potential was assessed from water/air and soil/air fugacity ratios (FRWA, FRSA), derived from HMB concentrations and their physicochemical properties. Equilibrium is indicated by FR=1, net deposition FR<1, net volatilization FR >1.

DAME concentrations in S/L ranged over three orders of magnitude, with higher concentrations in forests dominated by spruce versus pine ($p < 0.05$). BAs were highest in estuaries from in situ production and DAME was highest in rivers from terrestrial runoff. DA is a phenol and partly dissociated at environmental pH. The fraction of DA/(DA+DAME) was higher in VC rivers than in S/L, probably due to greater mobility of ionic DA. Net volatilization of BAs and DAME from water and DAME from S/L was indicated at most sites (FRWA and FRSA >1), concurring with reported findings in Canada (Zhan et al., 2023, Sci. Adv. 9, eadi8082). HMBs have environmental relevance. CFMs contribute to the land-sea transfer of total organically bound chlorine. BAs, DAME and DA bioaccumulate, and DAME is predicted to have toxic properties.

Disclaimer/Disclosure: This research is supported by the Swedish marine strategic research environment EcoChange (https://www.umu.se/en/ecochange/), Swedish Research Council Formas.

4.04.P-Th088 Characterization of Metal Bioavailability in Coastal Sediments of Iqaluktuuttiaq (Cambridge Bay), Nunavut, Canada

Camille Brice[1], Claude Fortin[1], Tamzin Blewett[2], Erin Leonard[3] and Anne Crémazy[1] (1)Institut National de la Recherche Scientifique (INRS), (2)University of Alberta, (3)Wilfrid Laurier University

The coastal environment of Cambridge Bay, located in the Kitikmeot region, Nunavut, Canada, was investigated to assess the ecotoxicological risks associated with metal contamination in Arctic ecosystems. The Canadian Arctic is home to several active mines and exploration projects aimed at extracting critical and strategic minerals. In the context of the energy transition, this region could face a substantial increase in contamination by trace metals and greater exposure of ecosystems to these contaminants. At the community scale, local sources of pollution, such as landfills and sewage, may also be major contributor to contaminant inputs in the bay.
This study focuses on strategic metals prioritized by the Canadian government (i.e. copper, cobalt, nickel, zinc and rare earth elements) and assesses their concentration, mobility and bioavailability in coastal sediments and

benthic organisms. Sampling sites were selected based on gradients ranging from minimally disturbed to heavily disturbed areas. The mobility and bioavailability of trace metals in sediments were measured in situ using DGT (diffusive gradients in thin films) probes deployed in the first 15 cm of sediments. This sampler provides the measurement of vertical profiles of labile (~bioavailable) metals in the porewaters as well as the resupply in time of dissolved metals from the sediments. Surface sediments and benthic organisms were collected at the same sites as well as in a grid covering the bay using a sediment grab. The tissues were digested and analyzed to measure metal accumulation, while the sediments were digested using total and sequential extraction to determine metal concentrations and partitioning in the solid phase. Sediment cores were also collected with a small gravity corer at selected sites to measure the vertical profiles of metal concentrations and provide insights on historic inputs and diagenetic processes. Together, data acquired with the DGT probes, the sediment samples and the benthic organisms will provide a comprehensive framework of metal spatiotemporal distribution, fluxes and path at the sediment-water interface, as well as bioaccumulation in benthic organisms. This approach will also determine whether sediment-derived metal fluxes reflect biological uptake and accumulation.

4.04.P-Th089 Nickel Sensitivity in a Natural Sea Ice Algal Community From the Arctic Ocean

Karima Hadria Gondry[1], Amandine Greil[1], Dylan B. Beard[2], Fleur Issac[2], Tamzin Blewett[2], Claude Fortin[1] and Anne Crémazy[1] (1)Institut national de la recherche scientifique, (2)University of Alberta

Sea ice algae play a vital role in Arctic ecosystems: they are one of the primary energy sources in the food chain and, as primary producers and support numerous organisms. These microalgae are already exposed to multiple seasonal environmental stresses, and the growing exploitation of mineral resources in the Arctic could introduce further disturbances to this ecosystem. Certain trace metals, such as nickel (Ni), may be among these. In this context, our study aims to assess the sensitivity of a natural community of ice algae exposed to Ni. We collected ice microalgae using an ice corer near the Canadian High Arctic Research Station (CHARS, Cambridge Bay, Nunavut) in May 2025. They were exposed for 11 days to different concentrations of Ni (ranging from 25 to 3000 µg/L), following acclimatization, in an environmental chamber at CHARS. Growth was estimated based on chlorophyll a measurement. We also measured several photophysiological parameters during exposure, as well as particulate organic carbon and nitrogen. At the end of the exposure, Ni bioaccumulation and fatty acid profiles were determined. Results show that Ni does not affect algal biomass or photosynthetic performance in this context. However, Ni influences fatty acid profiles by reducing the proportions of polyunsaturated fatty acids (PUFAs) and omega-3s. The responses of the natural community thus appear similar to those of a monoculture of Arctic microalgae previously studied in the laboratory.

4.04.P-Th090 Dipteran-Mediated Mercury Flux in Arctic Lentic Ecosystems: Implications for Terrestrial Food Webs

Matthew Chumchal[1], Emma Sullivan[1], Benjamin Strang[1], Kurt Burnham[2] and Kimberlee Whitmore[1] (1)Texas Christian University, (2)High Arctic Institute

At high concentrations, mercury (Hg) presents significant ecological risks to wildlife. Long-range atmospheric transport of Hg emissions from temperate and tropical regions can lead to contamination even in remote areas, such as the Arctic. In aquatic systems, atmospheric deposition of inorganic Hg can undergo methylation,

forming methylmercury (MeHg), a highly toxic and bioaccumulative compound. Emergent aquatic insects accumulate MeHg during their larval stage and transfer it to terrestrial ecosystems upon emergence as adults, potentially exposing terrestrial predators to contamination. This study quantified dipteran-mediated Hg flux—calculated as emergent dipteran biomass multiplied by MeHg concentration—in five ponds and one lake on the Pituffik Peninsula in the High Arctic of Northwest Greenland. Emergent dipterans were collected weekly over a six-week period (June–August 2023). Biomass and Hg concentrations varied across lentic ecosystems and dipteran taxa, leading to differences in dipteran-mediated Hg flux among ecosystems. A risk analysis indicated that insectivorous Snow Bunting (Plectrophenax nivalis) and Lapland Longspur (Calcarius lapponicus) chicks consuming only emergent dipterans would not be exposed to Hg concentrations high enough to pose a risk to their health.

4.04.P-Th091 Long Term Temporal Trends of PCBs and PBDEs in Landlocked Char in High Arctic Lakes: Influence of Local Sources Versus Long Range Transport

Derek Muir[1], Jane Kirk[2], Gerald Tetreault[3], John Chételat[3], Ana Cabrerizo-Pastor[4], Benjamin Barst[5], Günter Köck[6], Debbie Iqaluk[7] and Xiaowa Wang[3] (1)University of Guelph, (2)Environment and Climate Change Canada (ECCC), (3)Environment & Climate Change Canada, (4)Valladolid University, (5)University of Calgary, (6)Institute for Interdisciplinary Mountain Research, (7)Resolute Bay

Landlocked Arctic char (Salvelinus alpinus) are the only top predators in most high Arctic lakes and serve as sentinels for changes in atmospheric inputs of persistent organic pollutants (POPs) to remote freshwater environments. Polychlorinated biphenyls (PCBs) have been declining in air in the Canadian Arctic over the past 20 years while polybrominated diphenyl ethers (PBDEs) show slow declines after peaking in 2010. There are no other recent records (post 2010) of PCB or PBDE deposition, such as dated sediment or ice cores, in the Arctic. We hypothesized that the trends of PCBs and PBDEs in air would be reflected in the muscle of landlocked char in remote lakes receiving only atmospheric inputs to the lake surface and catchments. However, as two of our lakes were near the community of Resolute Bay, we also considered whether trends of PCBs and PBDEs were influenced by local sources.

Data were available for char from 2 very remote high Arctic lakes (Amituk, Hazen) and 2 (Resolute, Char) near Resolute Bay (pop 150), spanning up to 23 sampling years from the early-1990s to 2025, with sample sizes ranging from 3 to 10 fish per year. Temporal trends of lipid-normalized concentrations were analysed using HARSAT, an open-source, R-based statistical package. Total (Σ33)PCBs have declined significantly in all 4 lakes from the early 1990s to 2025. However, the decline has been more rapid in remote lakes (Amituk, -6.7 %/y; Hazen, -8.7%/y) than in Resolute (-3.5 %/y) and Char Lakes (-5.3 %/y). Total (Σ13)PBDEs increased significantly in char from Hazen (6.6%/y), Char (7.1 %/y) and Resolute (9.5 %/y) but not in Amituk (-2.6 %/y) from the early 2000s to 2017, and have declined in all lakes from 2017 to 2025. Declining PCBs in char from the 1990s is consistent with long term air measurements at Alert on northern Ellesmere Island. Previous PCB use at the airport and former military base, which are within the catchment of Resolute Lake, may explain the slower decline in that lake and nearby Char Lake. The increase of ΣPBDEs in char paralleled air measurements at Alert but contrasted with phase out of PBDEs in the mid-2000s in the USA, Canada and Europe. The greater rate of increase of PBDEs in char from Resolute and Char lakes up to 2017, may reflect poor solid waste handling in the community, which results in plastics and other light weight materials blowing from landfill site to lakes, then entering the lakes during the short open water season (July-September).

Disclaimer/Disclosure: The project has received long term funding from Canada's Northern Contaminants Program

4.04.P-Th092 Mercury Accumulation in Long-Lived Gulf of Alaska Fishes: Age, Growth, and Sex-Specific Patterns in Black Rockfish and Pacific Halibut

Isabelle Nelson[1], Benjamin Barst[2], Tamara Rivera[1], Kevin McNeel[3], Joan Forsberg[4], Darran May[4], Jessica Dutton[5] and Kristin Nielsen[1] (1)University of Texas Austin, (2)University of Calgary, (3)Alaska Department of Fish and Game, (4)International Pacific Halibut Commission, (5)Texas State University

Fishing dramatically affects many aspects of human health in coastal Alaskan communities through contributions to food security and nutrition, cultural continuity, and strong community relationships. Historically, rural Alaskans have relied heavily on subsistence harvests to meet basic nutritional needs; however, in recent decades, harvest masses have been declining statewide. Community members largely attribute this trend to concerns related to climate change and perceptions regarding contamination in traditional foods, particularly mercury. Studies have shown that the heavily glaciated Gulf of Alaska region has particularly high inorganic mercury yields, which can be microbially transformed into methylmercury, a neurotoxic and bioaccumulative form of mercury present in fish muscle. Methylmercury also biomagnifies and can reach potentially toxic levels in the muscle of high trophic level and/or long-lived fish species. We assessed mercury concentrations in long-lived resident marine fishes in the Gulf of Alaska that are also consumed as subsistence resources, including black rockfish (Sebastes melanops) and Pacific halibut (Hippoglossus stenolepis). Both species feed at relatively high trophic levels and have a lifespan that may exceed 50 years, predisposing them to dietary methylmercury accumulation. Despite these similarities, black rockfish and halibut use different habitats within the study area (e.g. pelagic versus benthic dwelling), which may influence their exposure. To examine longitudinal changes in mercury accumulation, we quantified total mercury in skeletal muscle, methylmercury in concentric eye lens layers, and used otoliths to estimate ages of individual fish. Black rockfish and Pacific halibut had similar total mercury concentrations; however, the relationship between body size and age differed considerably by species. Sampled black rockfish ranged from 5-37 years old with total mercury concentrations of 6-365 ng/g wet weight, whereas halibut ranged from 6-18 years old with total mercury concentrations of 26-278 ng/g wet weight. In halibut, this relationship was influenced by their extreme size differences at maturity due to sexual dimorphism. These findings demonstrate the importance of growth rate and life history in total mercury accumulation potential for marine fishes and underscores the usefulness of age estimates as a reliable predictor of total mercury in long-lived species.

4.04.P-Th093 Quantitation and Characterization of Microplastics in Five Species of Zooplankton From the Western Canadian Arctic

Haylee Hatton[1], Anne Munezero[2], Brooke Labine[2], Gary Stern[3], Liisa Jantunen[4] and Matthew Ross[2] (1)University of Alberta, (2)Department of Physical Sciences, MacEwan University, (3)Clayton H. Riddell Faculty of Environment, Earth, and Resources, University of Manitoba, (4)Air Quality Processes Research Section, Environment and Climate Change Canada

Microplastics are a global environmental concern and pervade marine ecosystems worldwide. Their small size (<5mm) makes them ingestible by zooplankton, potentially impacting their survival, feeding, and reproduction. It is, therefore, essential to understand the extent of uptake of microplastics by zooplankton. This study aimed to quantify and characterize microplastics in various species of marine zooplankton. Five different species of

zooplankton, as well as bulk zooplankton samples, were collected from five locations in the Canadian Arctic: Peel Sound, Northwest Passage, Amundsen Gulf, Beaufort Sea and M'Clure Strait using vertical (V-Tow) and obliquely towed (O-Tow) nets. Pooled zooplankton samples were rinsed with water to remove external microplastic contamination and digested with potassium hydroxide to break down tissue and the exoskeleton. Microplastics were isolated by filtration and identified using Raman microspectroscopy. Microplastics were quantified and characterized based on morphology and size. Preliminary findings revealed an average of 1.5 plastic particles per sample, with bulk zooplankton samples showing a concentration of 35.5 pcs/g, composed of predominantly fibres (97%) with an average length of 780 µm. Polyester and polyethylene were the most abundant polymers in the bulk samples. In individual zooplankton species, the average concentration was 40.2pcs/g, mainly fragments (71%) with an average size of 184 µm dominated by polystyrene and polycarbonate. The results of this study highlight the extent of microplastic pollution and provide a foundation for further research into its adverse effects on these organisms.

4.04.P-Th094 Microplastics in Ringed Seals (Pusa hispida) From Arviat and Resolute Bay, Nunavut, Canada

Haylee Hatton[1], Brynne Radford[1], Steve Ferguson[2], Magali Houde[3], Liisa Jantunen[4] and Matthew Ross[1]
(1)Department of Physical Sciences, MacEwan University, (2)Department of Fisheries and Oceans, (3)Environment and Climate Change Canada (ECCC), (4)Environment and Climate Change Canada

Ringed seals (Pusa hispida) play a crucial role in Arctic marine food webs, serving as predators of fish and invertebrates, and as prey for polar bears (Ursus maritimus). However, there is limited data on microplastic accumulation in Arctic pinnipeds, including ringed seals, a keystone species in the Canadian Arctic. To better understand the extent of ingestion and potential accumulation of microplastics in ringed seals from the Canadian Arctic, thirty ringed seal stomachs were collected in collaboration with Inuit Hunters and Trappers from Arviat and Resolute Bay, Nunavut, Canada, in 2021. To isolate plastics, stomach contents were sieved into five size fractions (<53 µm - 1000 µm), digested using 10% KOH, and vacuum filtered. All suspected microplastics underwent analysis by Raman microspectrometry to identify polymer type, and all identified microplastics were counted and categorized based on length, color, and morphology. A total of 60 microplastics were identified. Microplastics were present in 23 out of 30 (77%) seal stomachs, with abundances ranging from 0 to 6 particles per seal (mean= 2.1 ± 1.6 pcs/seal). Fragments were the most prevalent morphology identified (55%), followed by fibers (41%) and films (3.3%). The most abundant polymers identified were unidentified anthropogenic particles and polyester. There were no significant differences in microplastic abundances between seal sexes or between locations.This study provides new data confirming the presence and characteristics of microplastics ingested by ringed seals harvested in Arviat and Resolute Bay, and will provide baseline information for future plastic pollution monitoring programs in the region.

4.04.P-Th095 Multi Compartment Distribution of Polycyclic Aromatic Compounds in Arctic Sea Birds

Sithumi Yaddehige[1], Reyd Dupuis-Smith[2], Jennifer Provencher[3], Thor Halldorson[4] and Gregg Tomy[4]
(1)University of Manitoba, (2)Carleton University - Biology Department, (3)Environment and Climate Change Canada (ECCC), (4)Center for Oil and Gas Development

Polycyclic aromatic compounds (PACs) are a complex class of organic contaminants that are ubiquitous in the

environment. However, the persistence, bioaccumulation, and toxicity of most PAC subclasses remain poorly characterized. This is largely due to the chemical complexity of both parent PACs and their transformation products. Arctic seabirds are effective bioindicators of environmental contamination. They occupy high trophic positions and are exposed to a broad range of contaminants in Arctic environments. Nevertheless, little is known about tissue and organ-specific distribution patterns of PACs in seabirds. This study presents the first validated method for the simultaneous quantification of 122 homocyclic and heterocyclic PACs across five tissue types: muscle, blood, kidney, heart, and feathers. Quantification was performed by gas chromatography coupled to triple quadrupole mass spectrometry (GC-MS/MS), operating in dynamic multiple reaction monitoring (d-MRM) mode. This enabled full-suite PAC analysis in a single GC injection, substantially reducing analysis time relative to conventional MRM approaches. The method was validated in accordance with Eurachem guidelines. Extraction efficiency was assessed using spiked surrogate samples. The validated method was then applied to tissue samples collected from two Arctic seabird species: Common Eider (Somateria mollissima) and Black Guillemot (Cepphus grylle). Birds were sampled at the coastal communities of Nain (56.5417°) and Postville (54.9062°), Canada, following an oil spill in the Kaikopok Bay near Postville in 2020. Blood and feathers are the most frequently used non-lethal biomonitoring tissues. However, this study extended the analysis to five tissue types that differ substantially in exposure routes, metabolic activity and sampling invasiveness. Notable differences in PAC profiles were observed among species and tissue types, despite shared sampling locations. The factors driving these differences remain to be elucidated. This comprehensive approach represents a significant advancement in PAC exposure assessment, with direct implications for ecological, physiological and human health risk assessment in the Canadian Arctic.

4.04.P-Th096 The Chemical Eggsposé: A Spatial Analysis of Polycyclic Aromatic Compounds Across Canada

Ayesha Evelyn[1], Jordan Wong[1], Thor Halldorson[1], Jennifer Provencher[2], Reyd Dupis-Smith[3] and Gregg Tomy[1]
(1)Centre for Oil and Gas Research and Development, (2)Environment and Climate Change Canada, (3)Carleton University, Biology Department

There is a significant knowledge gap regarding polycyclic aromatic compounds (PACs) and the risk they pose to the environment and human health. PACs are now found across all environmental compartments, creating numerous exposure pathways and increasing the risks to both humans and wildlife. While regulatory bodies have enacted measures to limit production and release of certain PACs, environmental changes such as rising global temperatures and human activity may influence their distribution and concentrations. Therefore, it is essential to accurately identify and quantify PACs in the environment. This study investigates the spatial distribution of PACs and their possible toxicological effects in gull eggs from 19 locations across the Canadian Arctic. The regions examined spanned a longitude gradient of 43° to 67°. The homogenised eggs were analysed for 184 PACs including classes such as: homocyclic Polycyclic Aromatic Hydrocarbons (PAHs), heterocyclic PAHs, halo-PACs using a targeted analysis using tandem gas chromatography-mass spectrometric approach. A non-targeted analysis will be conducted using high-resolution mass spectrometry to discover new PACs in seabird samples. This research aims to support improved risk assessment and help anticipate potential ecological and human health impacts before widespread damage can occur.

4.04.P-Th097 Biomonitoring of Polycyclic Compounds in Common Eider Eggs

Jordan Wong[1], Ayesha Evelyn[1], Jennifer Provencher[2], Reyd Dupuis-Smith[3], Thor Halldorson[1] and Gregg Tomy[1] (1)Centre for Oil and Gas Research and Development, (2)Environment and Climate Change Canada (ECCC), (3)Carleton University - Biology Department

Polycyclic aromatic compounds (PACs) are ubiquitous environmental contaminants derived from natural sources, such as forest fires, and from industrial activities through the incomplete combustion of fossil fuels. Their persistence in the environment, potential to bioaccumulate, and toxicity to organisms make them priority targets for biomonitoring, particularly as industrial expansion into the Arctic intensifies. Here, we present two complementary studies using common eider (Somateria mollissima) eggs as a non-lethal biomonitoring matrix for PAC contamination along the Atlantic coast of Canada. The first study investigated spatial trends in PAC concentrations across four breeding colonies, using microbead extraction of egg contents followed by analysis via gas chromatography-tandem mass spectrometry. The second study examined within-clutch variation in PAC concentrations, testing whether laying order and clutch size influences the degree of maternal transfer of contaminants from the mother to eggs. Together, these studies will improve our understanding of PAC exposure pathways in marine birds and provide a baseline for tracking the environmental impacts of increasing Arctic industrialization. Our findings will elucidate how physiological and reproductive factors modulate contaminant transfer, with implications for interpreting biomonitoring data in colonial seabirds.

4.04.P-Th098 Mercury in Motion: Investigating Temporal and Interspecific Differences in Mercury Contamination in High Arctic Birds

Nicole Fordree[1], Matthew Chumchal[1], Kurt Burnham[2], Jennifer Burnham[3], Kimberlee Whitmore[1], Jeff Wesner[4], Camryn Middlebrooks[1], Titus Crawford[1], Abi Welch[1] and Fallon Meyer[3] (1)Texas Christian University, (2)High Arctic Institute, (3)Augustana College, (4)University of South Dakota

The Arctic is a sink for globally emitted mercury, where deposited mercury emissions can be converted into the toxic, bioavailable form, methylmercury, in aquatic environments. Organisms that feed in these environments accumulate methylmercury, which can cause adverse health effects in species like birds that are particularly prone to the negative health effects of methylmercury contamination due to their elevated trophic position within Arctic food webs. Temporal and interspecific variation in mercury concentrations in birds is highly variable within the Arctic, highlighting the need for direct measurements of contaminant levels in different regions to understand patterns of mercury contamination. However, there have been no studies investigating the long-term temporal variation and interspecific patterns of mercury in bird tissues from northwest Greenland. Our research aimed to assess how mercury contamination has changed over time from 2014 to 2024 and if mercury contamination patterns are related to differences in feeding ecology in four bird species that breed in northwest Greenland: thick-billed murres (Uria lomvia), black-legged kittiwakes (Rissa tridactyla), black guillemots (Cepphus grille), and common eiders (Somateria mollissima). Both blood and eggs were collected over the study period from bird colonies on the Pituffik Peninsula in northwest Greenland. Blood from adult birds was analyzed for carbon and nitrogen stable isotopes to assess interspecific differences in feeding ecology, while egg contents were analyzed for total mercury, a proxy for methylmercury, to assess temporal trends of mercury. Stable isotope analyses revealed that these four species feed in three distinct food webs. We found the highest concentrations of mercury in thick-billed murre and black guillemot eggs, followed by black-legged kittiwake eggs, and common eider eggs had the lowest. Concentrations of total mercury in common eider eggs

increased from 2014 to 2023, but no significant temporal trends were observed in other species. In the face of multiple stressors threatening Arctic ecosystems, monitoring mercury contamination is key to assessing the resilience of wildlife populations. This study will also provide insight into the effectiveness of global mercury-reducing initiatives like the Minamata Convention.

4.04.P-Th099 Occurrence of Fluorinated Compounds in Arctic Polar Bears and Seals

Yaseen Zaky[1], Michael Shields[1], Irvin Schultz[2], Kia Hayes[2], Li-Jung Kuo[2], Raphaela Stimmelmayr[3] and Yina Liu[1] (1)Texas A&M University, (2)National Oceanic and Atmospheric Administration (NOAA), (3)Department of Wildlife Management, North Slope Borough, Barrow, Alaska

Per- and polyfluoroalkyl substances (PFAS) are a diverse group of contaminants that are ubiquitous, persistent, and bioaccumulative, and pose a significant threat to global ecosystems. As apex predators, polar bears (Ursus maritimus) are vulnerable to PFAS exposure due to their high-trophic-level diet. This project examines the potential trophic transfer of PFAS within an Arctic predator-prey system comprising polar bears and three seal prey species: bearded, ringed, and spotted seals. We measured a suite of 40 legacy and emerging PFAS compounds in liver tissue samples via liquid chromatography-tandem mass spectrometry (LC-MS/MS). Perfluorooctanesulfonic acid (PFOS), perfluorononanoic acid (PFNA), and 3-perfluoroheptyl propanoic acid (FHpPA) were the most abundant PFAS compounds in the polar bears and seals, accounting for 75.4% of total PFAS (Range: 52.2% - 85.9%). Out of the 22 seal samples, PFNA was the dominant PFAS for 15 individuals (45.4% ± 6.4% of total PFAS concentration), and PFOS was the dominant PFAS for 7 individuals (37.9% ± 7.0% of total PFAS concentration). Out of the 20 polar bear samples, PFNA was the dominant PFAS for 17 individuals (40.0% ± 4.1% of total PFAS concentration), and FHpPA was the dominant PFAS for 3 individuals (35.4% ± 6.3% of total PFAS concentration). PFAS profiles in polar bears and seal species are further examined using multivariate statistics to shed light on possible trophic transfer pathways and ecological implications for these vulnerable apex predators.

4.04.P-Th100 Following PFAS Through the Canadian Arctic: Patterns in Ringed Seals, Seawater, and Influence of Environmental Factors

Nadia Facciola[1], Derek Muir[1], Amila De Silva[2], Steve Ferguson[3], Jane Kirk[2] and Magali Houde[2] (1)Environment and Climate Change Canada, (2)Environment and Climate Change Canada (ECCC), (3)Fisheries and Oceans Canada

The ringed seal (Pusa hispida) is an important cultural, economic, and subsistence species for Indigenous Peoples across Inuit Nunangat and it also serves as a keystone species for circumpolar contaminant monitoring. In the Canadian Arctic, concentrations of poly- and perfluoroalkyl substances (PFAS) have been measured in ringed seals and seawater for several decades. The objectives of this study were to (1) assess spatial and temporal trends of PFAS in liver tissues of ringed seals collected at four sites (Resolute Bay and Arviat, Nunavut; Sachs Harbour, Inuvialuit Settlement Region; and Nain, Nunatsiavut; 2000-2024), (2) compare seal and seawater PFAS patterns and concentrations over time around Resolute Bay, and (3) examine associations between seal PFAS concentrations and environmental/climate variables. Spatially, PFAS concentrations followed a consistent pattern of Arviat ≈ Nain > Sachs Harbour > Resolute Bay after accounting for temporal and biological variations (age, sex, body length, and stable isotopes). Across all analyzed PFAS in ringed seal liver, perfluorooctane sulfonic acid (PFOS) and long-chain perfluoroalkyl carboxylic acids (LC-PFCAs) (>C9)

dominated. Temporally, PFAS modelled trends (including biological and diet variables) were highly site- and compound-specific. At two of the four sites, PFOS decreased in the early 2000s following phase-out, increased during the late 2000s to 2010s, and has more recently declined again, with only some recent decreases reaching statistical significance. LC-PFCAs showed mixed trends across sites, including earlier increases followed by stabilization or recent declines. Patterns of contamination in seawater differed from those in seals, with shorter-chain PFAS more frequently detected in seawater. Seawater PFAS at Resolute Bay did not correlate significantly ($p>0.05$) with PFAS concentrations in seals sampled at the same site for corresponding years. This suggests either limited direct coupling between seawater and seal exposure, or that differences in temporal and spatial integration (lifelong accumulation in seals versus point-in-time seawater sampling) complicate direct comparisons. Analyses exploring links between PFAS in seals and environmental variables (sea surface temperature, wind speed, air temperature, salinity, Arctic oscillation, sea-ice coverage) are currently underway and will be presented at the meeting.

4.04.P-Th101 Changing Profiles of Carbon Homologue Groups of Polychlorinated Alkanes in Hudson Bay Polar Bears Over Four Decades and the Influence of Temporally Shifting Diet

Robert Letcher[1], Matthew Fredlund[2], David Blair[3] and Shaogang Chu[4] (1)Environment and Climate Change Canada (ECCC), (2)Nunavut Environment Department, (3)Environmental and Climate Change Canada, (4)Environment and Climate Change Canada

Chlorinated paraffins (CPs) are manufactured by the chlorination of paraffin fractions obtained from petroleum refining. CPs are mainly comprised of polychlorinated alkanes (PCAs) which are a complex mixture of congeners within short- (<C10 to C13), medium- (C14 to C17) and long- (C18 to >C20) chain carbon homologue groups (i.e. short-, medium- and long-PCAs). CP mixtures of PCAs are used in industrial and commercial purposes as flame retardants, plasticizers and metallurgy. Information about bioaccumulative CPs/PCAs in Arctic wildlife is limited mainly to short-chain PCAs. This includes the polar bear (Ursus maritimus) who is the apex of the Arctic marine food web and bioaccumulates high levels of persistent organic pollutants (POPs). In 2017, short-chain CPs (SCCPs) were listed under Annex A of the Stockholm Convention on POPs and medium-chain CPs (MCCPs) were listed in 2025. Presently, adipose (fat) tissue was sampled from 30 polar bears collected from adult male bears that were hunter harvested in 2023-2024 from communities in three different subpopulations in the western (WHB) and southern (SHB) Hudson Bay and Baffin Bay region in Arctic Canada. We developed a method to quantify individual carbon chain homologue groups of C9 to C20 PCAs in lipid-rich (i.e. polar bear fat) samples based on gas chromatography (GC) with high-resolution mass spectrometry (HRMS). Samples were extracted and then subjected to a freeze removal step where > 95 % of lipid was removed and then subject to further clean-up. Sample fractions were analyzed by GC with Orbitrap HRMS (in the NCI mode). Method limits of quantification for PCAs ranged from 1.1 to 17.5 ng/g wet weight. Mean recoveries of C9ClX to C20ClX homologues ranged from 56 to 120 % with a relative standard deviation of < 11 %. PCA analysis of the polar bear fat revealed that the homologue groups C9ClX to C18ClX were detectable whereas C19ClX and C20ClX were not detected in any of the 30 polar bear adipose samples. The highest total ΣPCA concentration was 48.2 ng/g wet weight. It generally appears that for all PCA homologue groups levels were higher in SHB versus WHB bears. We also report on an expansive PCA temporal trend study involving the analysis of n=151 bear fat samples collected over the period of 1983 to 2024 from adult males and females and subadults for SHB and WHB. Temporal trend PCA data are discussed in relation to

shifts in polar bear diet as the same fat samples were analyzed for 37 fatty acids.

4.04.P-Th102 Characterizing and Quantifying Metallic Nanoparticles in Arctic Beluga Whales (Delphinapterus leucas) Using Single Particle Inductively Coupled Plasma Time of Flight Mass Spectrometry (spICP-ToF-MS)

Chrystelle Lessard[1], Ariane Barrette[2], Houssame-Eddine Ahabchane[3], Pierre Ayotte[2], Marc Amyot[1] and Kevin Wilkinson[1] (1)University of Montreal (UdeM), (2)Laval University, (3)University of Montreal

Metal contamination in the Arctic environment and its animals poses significant environmental and health risks and is of particular concern for Indigenous communities that rely on marine mammals as a traditional food source. Therefore, protocols need to be developed to analyze metals present in these animals in all their forms, including metallic nanoparticles (NPs). For example, mercury-selenide (HgSe) NPs are recognized as a detoxification product of methylmercury, a highly toxic form of mercury, within the animals. For other NPs, their potential beneficial or detrimental effects on the health of humans and animals are still unknown. NP characterization is thus an important step towards a better understanding of their impact.

NP formation or accumulation is especially noteworthy for high trophic animals, like beluga whales (Delphinapterus leucas), which are frequently consumed by Arctic Indigenous communities. A protocol was first developed and optimized to extract the NPs found in the muscles, kidneys, brains and livers of 14 differently aged belugas, which includes a foetus and its mother. Subsequently, single particle inductively coupled plasma time of flight mass spectrometry (spICP-ToF-MS) was used to analyse the extracts, providing information on the masses and elemental compositions of single- and multi-element NPs. The highest number of NPs and particles were detected in the liver, followed by the kidney, the brain and the muscle. Multi-element particles were found in all organs, with most of them containing HgSe deposits. In adult beluga livers, up to 23% of the total mercury mass found was in the form of HgSe deposits. None of these particles were detected in the foetus' liver, while its mother had 2.6% of her total liver mercury in the form of HgSe. Silver was found to be quite prevalent in particle form, with up to 98% of the total mass of silver in adult beluga livers being detected as particles. Most of this silver was detected as silver-selenide deposits. In the muscles of adult belugas, that percentage comes down to 43%, but in the foetus' muscles, 87% of the total mass of silver was found to be in particle form. Silver particles were observed in nearly all samples.

These findings provide new insights into the inter-organ dynamic of NPs in belugas, could contribute to our knowledge of their origin and involvement in detoxification mechanisms, and may be useful in future toxicological and risk assessments in Arctic marine food webs.

4.04.P-Th103 Local Waste: A Source of Uncertainty in the Plastic Life Cycle in the Arctic

Adèle Luthi-Maire[1], Caroline Guilmette[2], Anne-Sophie Cloutier[3], Stéphanie Coulombe[4] and Julien Gigault[2] (1)Departement de Chimie, Université Laval, 1045 Avenue de la Médecine, G1V 0A6 Québec, Canada, (2)Takuvik International Research Laboratory, CNRS/Université Laval, 1045 Avenue de la Médecine, G1V 0A6 Québec, Canada, (3)Departement de Biologie, Université Laval, 1045 Avenue de la Médecine, G1V 0A6 Québec, Canada, (4)Polar Knowledge Canada, Government of Canada, Cambridge Bay, Nunavut, Canada

Arctic ecosystems are subject to plastic contamination through either global transportation from southern

ecosystems or, less documented, from local activities. From local sources, waste management faces urgent crisis principally due to the increase of anthropogenic materials and the accumulation of decades of waste in open-air areas that will degrade over time. A large part of this waste is systematically burned in the vicinity of the local communities, raising concern about the potential impact of the particles generated by this process.
In the present study we investigate the release of nanoplastics and by-products from this source in two Arctic communities: Cambridge Bay, Canada, and Ittoqqortoormiit, Greenland. In both villages, close to the waste areas, we sampled snow and plastic debris along a wind gradient. While nanoplastics and microplastics were extracted from snow samples, large plastic objects were put in culture in carbon-free media for one year to evaluate the potential release of by-products (nanoplastics, additives, depolymerization products) induced by biodegradation processes.
Thanks to a new analytical approach coupling thermodesorption and pyrolysis to a gas chromatography-mass spectrometry, we identified large quantities (until 20mg/L) of plastics. Interestingly, we observed a difference in the distribution over distance to the waste accumulation and incineration area: while polyethylene was observed at the incineration point, polystyrene is identified more than 200m to the source. Additives, such as phthalic anhydre or tributyl phosphate has been detected along the wind gradient as well as molecules known to be degradation product of plastic polymers (e.g. styrene or chlorobenzene), or additives (2,4-di-tert-butylphenol). One-fifth of cultures examined exhibited biological growth, thereby demonstrating that microorganisms can develop consuming carbon from plastic. DNA analyses have demonstrated substantial diversity between cultures. This phenomenon demonstrates the potential for adaptation of Arctic microorganisms to plastic contamination. A variety of molecules were identified, including additives along with depolymerization molecules (e.g. styrene, heptadecane) and nanoparticles of plastic. These results demonstrate that waste management in Arctic communities is an important source of plastic pollution in the arctic principally due to the incineration but also via long-term degradation such as erosion but also biodegradation.

4.04.P-Th104 Comparative Phytotoxicity of Energetic Materials in Arctic Soil: Implications for Ecosystem Resilience in a Changing Climate

Sabine Dodard[1], Marie-Josée Lorrain[1], Meiqun Wu[1], Meng Wei Ye[1], Nancy Perreault[1] and Marie-Claude Lapointe[2] (1)National Research Council Canada, (2)Defense Research and Development Canada

Rapid Arctic warming and permafrost thaw are changing how contaminants behave in northern environments, potentially increasing their movement and uptake by plants. At the same time, increasing military presence and related activities in the region raise concerns about the ecological impacts of energetic materials that maybe used in these operations. This study examined the phytotoxicity of two explosive formulations: Picatinny Arsenal Explosive (PAX-48, an insensitive munition) and composition C4, both amended separately in natural Arctic soil. Elbee Northern Wheatgrass (Elymus lanceolatus ssp. lanceolatus), a native Canadian species well suited for toxicity testing, was used. The energetic chemicals in PAX-48 include 3-nitro-1,2,4-triazol-5-one (NTO), 2,4-dinitroanisole (DNAN), and 1,3,5,7-tetranitro-1,3,5,7-tetrazoctane (HMX), while C4 only contains hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX). Boric acid was used as the reference toxicant for assay validation.
Wheatgrass germinated and grew well in the Arctic soil, confirming its suitability for bioassays. Boric acid showed reduced toxicity compared with artificial soil, suggesting lower boron bioavailability in the natural Arctic soil. PAX-48 caused strong, concentration-dependent inhibition of both germination and growth, indicating that its components were mobile and bioavailable under Arctic conditions. Chemical analysis

revealed that NTO was the most mobile compound, and its phytotoxicity was previously demonstrated by our team (EC50 = 1.9 mg/kg in plant assay); DNAN and HMX remained largely soil-bound. In contrast, C4, containing RDX, showed little effect on germination and only mild growth inhibition at very high concentrations.
Overall, PAX-48 posed a greater phytotoxic risk than C4, emphasizing the importance of formulation chemistry in determining environmental behavior and toxicity. These results suggest that climate-driven changes in soil temperature and moisture could further increase contaminant mobility and plant exposure. Understanding these processes is essential for predicting ecological risks and guiding management strategies to support vegetation recovery and soil health in rapidly changing northern ecosystem.

4.04.P-Th105 Diet Variability Drives Variation in Mercury Exposure and Toxicological Risk for Wolves in Canada and Alaska

Aaron Doerksen[1], Benjamin Barst[1], Gretchen Roffler[2], Gretchen Lescord[3], Daniel Dupont[4], Christina Prokopenko[5], Marco Musiani[6], Devin Kurelski[1], Grace Pigott[1], Tania Lewis[7], Tim Jardine[8], Angela Gastaldi[9], Abbey Wilson[10], Mathew Sorum[11], Matthew Cameron[11], Bridget Borg[12], Kelsey Stanbro[13] and Sterling Spilinek[13] (1)University of Calgary, (2)Alaska Department of Fish and Game, (3)University of Florida, (4)Université de Saint-Boniface, (5)University of Manitoba, (6)University of Bologna, (7)Glacier Bay National Park and Preserve, (8)University of Saskatchewan, (9)University of Alaska Fairbanks, (10)Government of the Northwest Territories, (11)Yukon-Charley Rivers National Preserve, (12)Denali National Park and Preserve, (13)Ahtna Intertribal Resource Commission

Methylmercury, produced primarily in aquatic environments, bioaccumulates and biomagnifies through food webs, posing health risks to long-lived apex predators. Wolves (Canis lupus) exhibit pronounced dietary plasticity, exploiting both terrestrial and aquatic resources, yet a broad scale mercury exposure and risk assessment has not been carried out for this terrestrial predator. We analyzed total mercury concentrations in hair from 971 wolves from 13 locations in Canada and Alaska. To infer feeding ecology for a subset of individuals (n = 300), we also measured bulk carbon and nitrogen stable isotope values. Hair total mercury varied widely (0.02–25.51 µg/g dry weight (dw); mean = 1.11 µg/g dw), likely reflecting both geographic and dietary differences. The highest hair total mercury concentrations occurred in interior wolves from Eastern Manitoba, where some individuals are likely consuming freshwater fish carcasses discarded by humans, and in coastal Alaskan wolves, which consume sea otters (Enhydra lutris). For a subset of samples, total mercury was strongly predicted by diet and trophic position, with no evidence of sex- or age-related differences. Most wolves (n = 942; 97%) were not at risk for toxic effects. Whereas 29 wolves (all from Eastern Manitoba and Southeast Alaska) had hair total mercury concentrations exceeding 9.27 µg/g dw, the level at which toxicological effects are more likely to occur, associated with aquatic prey consumption. The diets of Eastern Manitoba wolves were composed of up to 41% freshwater fish, and wolves in Southeast Alaska consumed up to 74% sea otters. By combining total mercury with carbon and nitrogen stable isotope data, we provide a broad geographic assessment of diet and risk for wolves and demonstrate how aquatic subsidies can elevate total mercury concentrations in both a coastal and interior terrestrial predator.

4.04.P-Th106 SPLINTER: A New Open Source Python Script for Determining Temporal Trends in Air Monitoring Data

Matthew MacLeod[1], Xiaoyu Zhang[1], Silke Cornelissen[1], Sabine Eckhardt[2] and Helene Lunder Halvorsen[2]

(1)Stockholm University, (2)Norwegian Institute for Air Research

Concentrations of persistent organic pollutants in air have been monitored at some reference sites in the Great Lakes and the Arctic for several decades. Time trends in these monitoring data provide critical inputs to effectiveness evaluation of the Stockholm Convention, and to environmental quality assessments by the Arctic Monitoring and Assessment Program (AMAP). Here we introduce a new open source Python script for determining temporal trends in long-term air monitoring data. SPLINTER (the linear SPLine Interannual Trend Evaluator) fits a generalized additive model (GAM) composed of linear spline and a Fourier seasonal components to monitoring data with outlier detection and removal. Candidate breakpoints in the linear spline function are determined using the RUPTURES breakpoint detection package, and SPLINTER evaluates a suite of candidate models with different breakpoints and selects the best model based on Bayesian Information Criterion. In this talk we describe the development of SPLINTER and optimization of breakpoint detection parameters using a suite of synthetic datasets. We illustrate its application to selected long-term air monitoring datasets for POPs in the Arctic from the EBAS database. SPLINTER results are already being incorporated into the 2026 update of the AMAP report on temporal tends of POPs in the Arctic, and we compare and contrast SPLINTER to the digital filtration fitting algorithm that was used in previous assessments. Key advantages of SPLINTER over the digital filtration fitting algorithm are 1) SPLINTER is open source software, 2) by fitting linear spline functions, SPLINTER results are readily interpretable as disappearance half-times, and 3) SPLINTER provides a set of user-specified options for handling data below the limits of quantification (LOQ) or detection (LOD). Plans for the continued development of SPLINTER, including integration of the code into the EBAS online database will be discussed.

4.04.P-Th107 Multi-Biomarker Health Assessment of Arctic Char (Salvelinus alpinus) From Paired High Arctic Lakes Impacted by Climate Change

Gemma Macfarlane[1], Melissa Lafrenière[2], Carl Mitchell[3], Jane Kirk[4], Gerald Tetreault[4], John Chételat[4], Kyle Wilson[5], Matt (Mathilakath) Vijayan[1], Margo Leggatt[1] and Benjamin D. Barst[1] (1)University of Calgary, (2)Queen's University, (3)University of Toronto, (4)Environment and Climate Change Canada (ECCC), (5)Simon Fraser University

Climate-driven changes are rapidly altering High Arctic lakes and their catchments. Despite their proximity (< 1km) and similar size, West and East Lakes at Cape Bounty on Melville Island, Nunavut (74° 53’ N, 109° 34’ W) have distinct catchments and are being affected differently by climate change. Although permafrost degradation has occurred at both sites, West Lake catchment and a series of underwater mass movement events within West Lake itself began following the particularly warm summer of 2007. West Lake turbidity increased by ~50x relative to that observed in East Lake. Landlocked Arctic char (Salvelinus alpinus), the only fish species present in both lakes, show poorer body condition in West Lake. This contrast between lakes offers a natural setting to assess how climate-related processes influence trace element inputs, bioaccumulation, and fish health in High Arctic lakes. The objectives of this study are to: (1) quantify trace element concentrations in water, sediments, and permafrost cores from both lake catchments; and (2) measure physiological responses of Arctic char to elevated trace element concentrations and total suspended solids. Water, sediment, permafrost, and fish tissues (gill, liver) from both lakes will be analyzed for trace elements. Arctic char blood serum, liver, and gill tissues will be analyzed for oxidative stress biomarkers, blood biochemical markers of liver function, and gill histopathology. We also aim to evaluate whether blood serum can serve as a non-lethal proxy for trace element exposure and effect.

We hypothesize that: (1) West Lake will exhibit higher trace element concentrations as a result of enhanced permafrost degradation in its catchment; and (2) Arctic char in West Lake will exhibit higher trace element accumulation, elevated oxidative stress, and increased gill damage relative to East Lake char.
As global warming intensifies, it is increasingly urgent to understand how climate-driven changes and sediment disturbances mobilize trace elements into Arctic lake ecosystems. Given that a recent study demonstrated increased turbidity in 288 High Arctic lakes due to permafrost degradation, our findings from East and West Lakes may reflect how the health of Arctic char is potentially affected across impacted lakes, and how High Arctic lake ecosystems may respond to continued climate warming.

Beyond Detection: Advancing Passive Sampling for Exposure Characterization, Source Tracking and Risk Assessment

4.05.T-01 Characterising Emerging Contaminants in the Urban Coastal Zone of the Galápagos Islands Using Novel 3D-Printed Passive Sampling Devices

Georgie Savage[1], Stephanie Andrews[1], Alexandra Richardson[2], Leon Barron[2], Ricardo Zambrano[3], Alfonso Velasteguí-Arias[4], Jen Jones[5], Ceri Lewis[1] and Tamara Galloway[1] (1)University of Exeter, (2)Imperial College London, (3)Conservation International, (4)Galapagos National Park Directorate, (5)Galapagos Conservation Trust

Assessing the environmental occurrence and fate of contaminants of emerging concern (CECs) is particularly challenging in the geographically isolated, (sub)tropical island system of the Galápagos Archipelago. Rapid population growth, urbanisation, agricultural intensification and inefficient wastewater treatment – confounded by minimal regulatory oversight – are amplifying episodic inputs of complex CEC mixtures to the environment. Assessments are further constrained by limited infrastructure, funding and analytical capacity. This study employed novel passive sampling devices (PSDs) – proposed as valuable monitoring tools for remote regions – to characterise CEC exposure in the urban coastal zone of populated Galápagos Islands. Compact 3D-printed methacrylate housing encasing five hydrophilic-lipophilic balance sorbents, were distributed in duplicate at twelve sites for seven days (n = 24), with paired 30 mL seawater grab samples collected on deployment and retrieval (n = 24). Targeted LC-MS/MS analysis identified 59 compounds (35 quantifiable) on 3D-PSDs, compared to 27 compounds (17 quantifiable) in seawater grab samples. Pharmaceuticals and personal care products dominated detections (69.4%), followed by pesticides (16.6%) and illicit drugs/metabolites (14.0%). The compounds most frequently identified or measured at the highest concentrations were benzoylecgonine (metabolite of cocaine; in 58% of samples) and valsartan (angiotensin; 2.7 ± 2.3 ng disc-1) on 3D-PSDs, and rizatriptan (migraine medication; in 75% of samples) and benzoylecgonine (1,309.5 ± 413.8 ng L-1) in seawater grab samples. Sulfamethoxazole (antibiotic) and terfenadine (antihistamine) exhibited the highest Risk Quotients (RQ > 10) when exposure concentrations were compared to relevant PNEC values. 3D-PSDs significantly increased detection and quantification probabilities by 2.18 and 2.54-fold, respectively ($p < 0.05$). The magnitude of enhancement was highly compound-specific, with the greatest improvements observed for compounds that presented low baseline characterisation in seawater. 3D-PSDs enabled the capture of temporal variability and fluctuating contributions from urban run-off, drainage overflows and wastewater effluent. This study provides an initial assessment of the CEC landscape of the Galápagos, highlighting priority contaminations, point-sources, and the application of a novel PSDs to support ongoing conservation of this dynamic island system and its unique biodiversity.

Disclaimer/Disclosure: This investigation was conducted under research permits issued by the Galápagos National Park Directorate (PC-52-24) and supported by the UKRI Global Challenges Research Fund 'Reducing the impacts of plastic waste in the Eastern Pacific Ocean' (NE/V005448/1).

4.05.T-02 Passive Sampling To Help Understand DDT+ Over the Decades in Southern California Waters Impacted by DDT Discharge and Dumping

Charles Wong[1] (1)Southern California Coastal Water Research Project (SCCWRP)

The coast offshore southern California is heavily contaminated with DDT, its degradates, and related contaminants (DDT+). This contamination arose from disposal of DDT wastes, discharged through the sewer system and by direct offshore ocean dumping, from the former Montrose manufacturing facility, the largest DDT manufacturer in the United States. As a result, the Palos Verdes Shelf (PVS) is a USEPA Superfund site, and more recently discovered contamination further offshore from past open-ocean dumping is under current study. Understanding the spatial and temporal extent of DDT+ contamination is essential in guiding remediation efforts. This presentation discusses the vital role of passive samplers over the decades to identify and characterize DDT+ compounds in the surface waters and sediment porewaters offshore southern California. These studies have played a role in formulating USEPA's 2009 Interim Record of Decision for Monitored Natural Recovery (MNR) of the PVS Superfund site, and in each of the two MNR studies that have subsequently taken place, in 2013 and 2022. In such studies, passive samplers of two types (solid-phase microextraction, SPME; and polyethylene strips, PE) were deployed at various locations and depths in the water column and/or sediment porewaters as applicable. Fluxes of dissolved-phase DDT from the sediments to the water column were evident, with total DDT concentrations at PVS in 2022 from 98-7300 pg/L, primarily from p,p'-DDE and p,p'-DDMU. Concentrations were greatest 4 km northwest of wastewater treatment outfalls from which the original discharges from Montrose had once come, and followed the primary current direction in the Southern California Bight in this area. Water column levels were consistent with routine monitoring of DDT concentrations in surface sediments since 1994. Only limited changes in fluxes and concentrations have been observed from 2013 to 2022, consistent with the overall evaluation from the MNRs that slow concentration declines remain high enough to be of concern in the water column, sediments, and biota. Further offshore at the dump sites, concentration gradients indicate sediment-water transport of DDT compounds at 900 m depth, consistent with observations at the much shallower PVS (tens of m depth). These measurements over the decades help formulate both suitable hazard assessment and remediation options, which USPEA is evaluating for its upcoming Record of Decision at PVS.

4.05.T-03 Effects Based Monitoring Using Passive Sampling and Transcriptomic Bioassays

Elli Hung[1], Hugo Marchand[1], Rheina Hawabhay[1], Caroline Demers[2], Gabriel Munoz[3], Marie-Claire Grenon[3], Stéphane Bayen[1] and Jessica Head[1] (1)McGill University, (2)Centre d'expertise en analyse environnementale du Québec (MELCCFP), (3)Centre d'expertise en analyse environnementale du Québec (MELCCFP)

Monitoring complex mixtures of anthropogenic chemicals in aquatic environments is a major analytical and ecological challenge. Each waterway has unique characteristics and contaminant loads that impact aquatic life differently, making it difficult to replicate these multiple stressors in a controlled laboratory setting. Traditional water quality monitoring relies on grab water sampling and targeted chemical analyses, which typically

overlooks non-targeted contaminants and their transformation products. Additionally, analytical chemistry alone does not directly inform the biological effects of these contaminants. To gain a holistic understanding of the contaminants present in riverine ecosystems through a biological lens, we are developing a transcriptomic bioassay using larval zebrafish exposed to reconstituted extracts of Polar Organic Chemical Integrative Samplers (POCIS). These field samplers provide a proxy for the fraction of contaminants that are bioavailable to aquatic organisms in the water column. As a proof of concept, POCIS were deployed in the Richelieu River (southern Québec, Canada) for one month in the winter and summer of 2025. POCIS extracts were serially diluted to generate exposure solutions in a 24-hour assay using larval zebrafish (Danio rerio). RNA was analyzed using the novel zebrafish EcoToxChip, a qPCR-based tool targeting over 370 genes involved in key toxicity pathways. Differential expression analysis using EcoToxXplorer revealed that 2 genes were upregulated across all the summer extract dilutions. Winter extracts induced a stronger response, with substantial gene upregulation and downregulation observed across several exposure concentrations. Several DEGs are shared between the extracts, notably genes implicated in aryl hydrocarbon receptor (AHR) signalling pathways and members of the cytochrome P450 (CYP) family. Ongoing work will integrate LC-MS-based non-targeted chemical analysis to compare contaminant profiles. This project demonstrates the potential of combining passive sampling with transcriptomic bioassays as an effect-based monitoring approach to characterize the biological impact of complex contaminant mixtures.

4.05.T-04 Embracing Passive Samplers for Contaminant Monitoring: Successes, Challenges and Prognosis From a Laboratory Perspective

Bharat Chandramouli[1], Million Woudneh[2] and Terry Obal[2] (1)SGS AXYS Analytical Services Ltd., (2)SGS

Passive sampling for organic contaminants has become increasingly common as a sampling strategy. Its use cases include the collection of time-averaged data, more realistic assessment of porewater concentrations, representative measurement of contaminant accumulation in organisms, and improved convenience and cost-effectiveness. Depending on chemical properties, a range of passive sampling media are available to maximize capture efficiency and support quantitative interpretation.

Despite extensive use in research, widespread adoption in compliance and regulatory settings, along with support from commercial laboratories, remains limited. In this study, we present three use cases where we supported both the preparation of passive samplers and the analytical measurement of a wide range of organic contaminants, including PPCPs, PCBs, PAHs, and PFAS. We discuss key successes, challenges encountered, and future directions for passive sampling programs.

Case study 1 summarizes a recent interlaboratory comparison evaluating polyethylene and polydimethylsiloxane samplers for sediment porewater measurement. Results demonstrated sufficient accuracy and precision across laboratories to increase confidence in their application for regulatory purposes.

Case study 2 compares semi-permeable membrane devices (SPMDs) and Polar Organic Chemical Integrative Samplers (POCIS) with co-located measurements in dreissenid mussels to assess biomonitoring potential. Correlations between passive samplers and mussel concentrations varied with chemical properties: PAHs measured using SPMDs showed strong agreement, while POCIS preferentially accumulated more polar contaminants, contrasting with mussel uptake of legacy hydrophobic compounds.

Case study 3 evaluates POCIS samplers for regional monitoring of PPCPs and hormones in an urban estuary. Results demonstrated their effectiveness in identifying wastewater intrusion, with elevated levels of sucralose, additional wastewater indicators, and several steroid hormones observed.

Overall, the laboratory experience highlights the importance of standardization to improve acceptance and support broader implementation of passive sampling in monitoring and regulatory frameworks.

4.05.T-05 Passive Samplers Provide Integrative Measurement of PFAS in Tidal Surface Water

Rachel Zajac-Fay[1], Jason Conder[1], Elizabeth Nichols[1], Brent Pautler[2], Nicholas Hayman[3] and Anita Thapalia[4]
(1)Geosyntec Consultants, Inc., (2)SiREM Lab, (3)Naval Information Warfare Center Pacific (NIWC Pacific), (4)Exxon Mobil

A dialysis-based passive sampler was used to measure concentrations of PFAS in surface water at a saltwater tidal site that receives PFAS via flow of groundwater (through the subsurface) from an adjacent uplands source of PFAS. Co-located surface water grab samples were collected at the time of the passive sampler deployment and retrieval (deployment period of 14-days). The freely dissolved concentration (Cfree) measured by the passive sampler was compared to the average concentration of the surface water grab samples; only 40% of Cfree PFAS measurements were within a factor of 3. When looking at individual grab samples, 83% of Cfree measurements were within a factor of 3 during the deployment, but only 27% were within a factor of 3 during the retrieval event. During both sampling events, surface water grab samples were collected at relatively low tides. At five of the ten stations, samples were collected at similar points in the tidal cycles. Specifically, surface water grab samples at deployment from the five stations were obtained approximately 4 to 6 hours after the previous high tide, whereas the retrieval grab samples were obtained approximately 6 to 9 hours after the previous high tide. Concentrations of total PFAS in the retrieval surface water grab samples at the five stations were (on average) an order of magnitude higher than the deployment samples; concentrations of PFAS in water increased with time after the previous high tide ($r2 = 0.80$). Given that a main source of PFAS to these stations originates from groundwater flux outward to the shoreline, the longer the tide is out, the more groundwater (containing PFAS) likely seeps out of the shoreline, resulting in higher PFAS concentrations in offshore surface water. Overall, surface water grab samples collected at low tide provide a snapshot of PFAS that will tend to capture the highest concentrations of PFAS, whereas Cfree measurements provide an integrative measurement of PFAS that will tend to measure an average over the tidal cycles during the 14-day deployment period. Such an integrative measurement may be more appropriate for use in risk assessments to evaluate the average PFAS exposures of aquatic life. This study shows that PFAS passive samplers can provide credible data on the nature and extent of PFAS in aquatic systems and augment more traditional grab sampling to provide a potentially more useful estimate of exposure.

Disclaimer/Disclosure: Funding support for this project provided by ESTCP (project ER23-7741) and ExxonMobil Environmental and Property Solutions Company.

4.05.T-06 Atmospheric Concentrations of per- and Polyfluoroalkyl Substances (PFAS)

Along the Delaware River and Implications for Surface Water Contamination

Melissa Woodward[1], Jitka Becanova[1], Simon Vojta[1], Jeremy Conkle[2] and Rainer Lohmann[1] (1)University of Rhode Island, (2)Delaware River Basin Commission (DRBC)

Per- and polyfluoroalkyl substances (PFAS), a class of emerging organic contaminants of concern, have been released into the environment for over 60 years and are known for their environmental ubiquity, persistence, and toxicity to life. Despite this, atmospheric concentrations of PFAS, their transport, and impact on surface water are not well understood nor widely researched. This study utilizes a novel passive sampler combined with water samples to investigate the relationship between atmospherically transported PFAS and surface water concentrations through monthly deployments over a year in New Jersey and along the Delaware River. ΣPFAS atmospheric concentrations ranged from 0.01 ng/m3 to 5.9 ng/m3 (median 2.3 ng/m3), with 6:2 fluorotelomer alcohol (FTOH) being the dominant compound with a detection frequency (d.f.) 100 % and ranging from 1.6 ng/m3 to 2.7 ng/m3 (median 2.0 ng/m3). ΣPFAS water concentrations ranged from 8.5 ng/L to 14.5 ng/L (median 13.3 ng/L), with perfluorooctanoic acid (PFOA) being the dominant compound with a detection frequency (d.f.) 100 % and ranging from 1.1 ng/L to 2.0 ng/L (median 1.7 ng/L). Despite co-occurrence of PFAS in air and water, no significant correlations were observed between atmospheric and surface-water concentrations based on targeted PFAS measurements. Additional analyses are ongoing to further evaluate atmospheric contributions to surface-water PFAS burdens. In the atmosphere, comparison of different co-deployed atmospheric samplers identified perfluorobutanoic acid (PFBA) as having preference for the particle-phase, whereas perfluorobutanesulfonic acid (PFBS) was detected more in gas-phase. Observed differences in atmospheric PFAS concentrations suggest population density and associated anthropogenic activities, along with seasonality, influence atmospheric PFAS burdens. For example, in Trenton (~4,500 people/km2) ΣPFAS was 3.7 ng/m3 and 5.6 ng/m3 for winter and summer, respectively. Whereas in Stockton (~400 people/km2) ΣPFAS was 1.9 ng/m3 for both winter and summer. Overall, year-long passive sampling revealed seasonal and spatial trends in atmospheric PFAS occurrence, highlighted the complexity of atmospheric-surface water interactions, and demonstrated the value of passive sampling for long-term PFAS monitoring and source characterization.

Beyond Detection: Advancing Passive Sampling for Exposure Characterization, Source Tracking and Risk Assessment

4.05.P-Th129 Using Performance Reference Compounds To Assess Diffusion Kinetics of Peeper Passive Samplers To Measure the Availability of Inorganics

Florent Risacher[1], Jason Conder[1], Brent Pautler[2] and Gunter Rosen[3] (1)Geosyntec, (2)SiREM, (3)N/A

Dialysis passive samplers (peepers) allow in situ measurement of bioavailable metals in sediment porewater, but long equilibration times and a lack of standardized, efficient, and thoroughly tested methods have limited their use in time-sensitive environmental monitoring and risk assessment. This presentation will showcase laboratory and field studies demonstrating how performance reference compounds (reverse tracers) in peepers enable the use of diffusion modeling to accurately estimate true (equilibrium) porewater concentrations. Laboratory tests were conducted using peepers deployed for multiple time periods over the course of several weeks, including short deployments that were insufficient to achieve full equilibrium. Results showed that when the tracer (lithium bromide) reached ~50–75% of equilibration, diffusion modeling accurately predicted

equilibrium concentrations of seven metals (Cd, Cr, Cu, Hg, Ni, Pb, Zn) within ~20% of their actual values. A ten-day field deployment in sediment and surface water achieved ~90% tracer equilibration, with target metals reaching ~70–90% of equilibrium, confirming that reliable porewater contaminant measurements can be obtained in ~1 week using the peeper designed in this study. These findings indicate that peepers with ~50–75% tracer equilibration which can typically be reached within about 4–7 days under sediment conditions can provide robust estimates of metal porewater concentrations via diffusion-based modelling. Additionally, deployments achieving ≥ 90% tracer equilibration (in ~10–21 days) yield direct evidence of near complete equilibrium, providing valuable proof of available porewater metal concentrations. By guiding deployment duration and post-deployment modeling, this tracer-aided approach ensures passive sampling results reflect actual contaminant availability, thereby improving the utility of peeper data for environmental monitoring, and increasing confidence in contaminant exposure data used for ecological risk assessment.

4.05.P-Th131 In-Situ Calibration of Passive Samplers for Monitoring Persistent, Mobile, and Toxic Plastic Additives in Wastewater

Ericka De Oliveira[1], Nathalia Bastos[1], Eric Fries[1], Paul Helm[2] and Roxana Suehring[1] (1)Toronto Metropolitan University, (2)Ontario Ministry of the Environment, Conservation and Parks

Persistent, mobile, and toxic (PMT) substances are an emerging class of contaminants increasingly detected in urban-impacted waters. Several plastic additives meet PMT criteria, underscoring the need to better characterize their environmental occurrence and associated risks. Their high water solubility, resistance to degradation, and inherent toxicity pose risks to aquatic ecosystems and drinking water. However, PMT plastic additives are difficult to monitor using conventional grab sampling because they often occur at low concentrations and fluctuate over time. Passive sampling offers a promising alternative by accumulating contaminants over time to provide time-integrated measurements and improved detection. Yet, PMT plastic additives remain largely uncharacterized in passive sampling frameworks, and the calibration data needed to interpret uptake behavior are limited.

This study presents an in-situ calibration experiment evaluating two passive sampler types—Hydrophilic-Lipophilic Balance (HLB) disks and polydimethylsiloxane (PDMS) silicone strips—for monitoring PMT plastic additives. Samplers were deployed for 51 days in the secondary treatment tank of an Ontario wastewater treatment plant, alongside composite water sampling to provide aqueous-phase concentrations. Sampler extracts were analyzed using high-performance liquid chromatography quadrupole time-of-flight mass spectrometry (HPLC-QTOF-MS) with a suspect screening workflow targeting 124 plastic additives registered for use in Canada. Sampling rates (Rs) and sampler–water partition coefficients (Ksw) were calculated from time-series uptake data.

A total of 39 PMT plastic additive suspects were detected on HLB, 28 on PDMS, and 59 in the composite wastewater samples. HLB exhibited predominantly linear, kinetic-phase uptake across most suspects, suggesting suitability for time-integrated quantification. In contrast, PDMS behaved largely as an equilibrium sampler, indicating rapid equilibration for certain PMT substances. These differences highlight the complementary nature of these sorbents when monitoring structurally diverse, mobile plastic additives. This study provides the first in-situ calibration datasets for PMT plastic additives in wastewater. The resulting Rs and Ksw values will support more accurate environmental concentration estimates, enable wider passive sampling applications across Ontario, and provide essential tools for future chemical management policies in Canada.

4.05.P-Th132 Assessing PCB Remediation in Schools With Passive Emission Samplers

Jason Hua[1], Rachel Marek[1], Lillian Montabon[1] and Keri Hornbuckle[1] (1)University of Iowa

Schools constructed before 1980 in the United States may contain caulk, sealants, plasticizers, light ballast capacitors, and flame retardants that are still emitting toxic polychlorinated biphenyls (PCBs) decades after installation. Remediation of PCB sources are required to prevent staff and student exposure. In this study, we evaluated the effectiveness of multiple remediation strategies in three Vermont schools, subject to state regulation of PCBs in air, by measuring PCB emissions from surfaces and concentrations in air before and after corrective actions. Passive air samplers (PUF-PAS) and passive emission samplers (PUF-PES) were deployed in rooms that had undergone remediation. Two major sources specifically, spray-on fireproofing and joint sealants, were targeted for remediation because of their significant PCB emissions, ranging 150,000 – 830,000 ng m-2 d-1. Overall, emissions were substantially reduced after targeted remediation (80–99%), but decreases in air concentrations were inconsistent (0 – 85%). Air concentrations alone may not adequately reflect remediation effectiveness due to environmental variability and unaddressed sources. We found that primary source removal combined with encapsulation was the most effective remediation approach, reducing surface emissions by 93.5–99.9%. Source removal alone achieved moderate reductions (~84%), while primary source encapsulation was less effective, particularly for high-emitting materials. We also found that emissions from nonprimary surfaces can be significant contributors to airborne PCBs and remained elevated unless explicitly treated. Therefore, secondary and tertiary emissions must also be addressed during remediation. We then performed a mass balance for one room incorporating measured emissions, ventilation, and deposition. Despite the difference in emission magnitude, nonprimary emissions dominate the room's total emissions due to their surface areas, limiting reductions in airborne concentrations. We propose an emissions-based framework to quantify remediation success and estimate allowable emission rates needed to meet air quality targets. Overall, a comprehensive, whole-room approach addressing both primary and nonprimary sources is essential for effectively reducing PCB exposure in schools. Our findings exemplify the use of direct surface emission measurement for streamlining targeted remediation decision making and assessing effectiveness of remediation throughout a room.

4.05.P-Th133 Silicone Passive Emissions Sampler (Si-PES) To Quantify Contribution of Building Materials to Polychlorinated Biphenyl (PCB) Concentrations in School Air

Lillian Montabon[1], Jason Hua[1], Rachel Marek[1], Trevor Erb[1] and Keri Hornbuckle[1] (1)University of Iowa

PCBs can be emitted into the gas phase from building materials via primary, secondary, and tertiary sources. Primary sources are materials containing intentionally added PCB mixtures (e.g., Aroclors), such as window caulk. Secondary sources form when PCBs diffuse into adjacent solids (e.g., brick or plaster), which then emit them, while tertiary sources result from the re-emission of PCBs deposited onto indoor surfaces over time. Materials acting as secondary reservoirs may contain PCB concentrations exceeding the 50 ppm Environmental Protection Agency (EPA) limit, but the extent to which secondary-source emissions influence airborne PCB levels remains unclear. We designed a silicone-based passive emissions sampler (Si-PES) to evaluate PCB migration by collecting emissions from building materials immediately adjacent to primary sources. The Si-PES sampler uses a silicone strip to collect volatilized PCBs released from a surface, an aluminum channel to provide rigidity, and accordion folded aluminum foil to hold the silicone in place. To compare mass flow rates of PCBs from primary, secondary, and tertiary sources, we deployed a series of Si-PES units on building

materials at increasing distances from primary sources in multiple schools. We also deployed polyurethane passive emissions samplers (PUF-PESs) on suspected tertiary sources and collected bulk samples of concrete, sheetrock, and paint at increasing distances from a primary source. We analyzed these samples for all 209 PCB congeners using gas chromatography with triple quadrupole mass spectrometry. We compared the trend in PCB emission rates with increasing distance from a primary source to the trend in PCB concentrations in the same material with increasing distance from the primary source. To help guide remediation efforts, we calculated the relative contribution of primary sources, sources adjacent to primary sources, and tertiary sources to PCB concentrations in indoor air.

4.05.P-Th134 Using Spatial Trends in the Prioritization of Features Detected in the Non-Target Analysis of XAD-2 Resin Based Passive Air Samplers To Determine Source Characteristics of Gas-Phase Contaminants

Jenny Oh[1], Chubashini Shunthirasingham[2], Adrià Sunyer-Caldú[3], Alexander Kasperkiewicz[1], Stefano Papazian[3], Faqiang Zhan[1], Yuening Li[1], Ying Duan Lei[1], Hayley Hung[2], Jonathan Martin[3] and Frank Wania[1] (1)University of Toronto, (2)Environment and Climate Change Canada (ECCC), (3)Stockholm University

The rapidly increasing production and usage of chemicals has led to complex mixtures of pollutants in the environment, with potentially harmful exposure of humans. Non-target analysis (NTA) is therefore becoming a popular approach to enable a broader coverage of compounds present in environmental samples. NTA workflows are often streamlined with offline prioritization methods to select chemical features of interest for further analysis. Among these techniques are “differential analyses” that rely on differences in feature presence and intensity between samples, such as analyzing statistical relationships between signal intensities for features observed in samples distributed in space. We developed and optimized a workflow for the NTA of extracts obtained through XAD-2 resin-based passive air sampling, suitable for analysis by both gas and liquid chromatography coupled to high-resolution mass spectrometry (GC- and LC-HRMS), with extracted features screened against in-house and publicly available databases. As an application of this workflow, we use differential analysis based on spatial patterns to identify features detected in the LC- and GC-HRMS-based NTA of XAD-based passive air samplers (PAS) obtained from large PAS networks across the coastal regions in British Columbia (BC) and Quebec (QC) that have common source characteristics. 70+ compounds were identified (level 1) in 71 air samples, with several of them quantified. Because PAS from the same networks had been subjected to targeted analysis before, spatial patterns of previously targeted substances could serve in the identification of features with similar spatial distributions. For example, a municipal waste incinerator in Quebec City had previously been identified as a source of polychlorinated biphenyls (PCBs) to the surrounding area. Many features, including benzene sulfonamide and N-butylbenzenesulfonamide (level 2), had a similar spatial distribution to the PCBs within Quebec City, highlighting the potential of the incinerator to be a point source of numerous atmospheric contaminants. Using this approach and previously targeted organophosphate esters known to be emitted during consumer product use (e.g. tris(chloropropyl) phosphate), numerous features whose signal intensities have a spatial pattern correlated with population density could be identified. Similarly, we identified substances with spatial pattern correlated to traffic intensity and biomass burning.

4.05.P-Th135 Phthalate Exposure, Fate, and Human Health Risk From Artificial Turf

Kelly O'Malley[1], Alison Clark[1], Lane Tidwell[1], Isabella Nelson[1] and Kim Anderson[1] (1)Oregon State University

Phthalates have been previously detected at artificial turf fields with crumb rubber infill, and exposure concerns to field users exist due to their association with reproductive and developmental toxicity. More recently, fields are beginning to be installed with alternative infills to reduce chemical exposure. It is unknown how phthalates move between turf and the overlying air, which would provide additional insights into exposure. Low-density polyethylene (LDPE) passive samplers have been used extensively to quantify environmental concentrations for many chemical classes, but not previously for phthalates. Paired air and turf pore air LDPE samplers were deployed concurrently at 10 artificial turf fields for 28 days to determine how field location (indoor vs outdoor), infill type (crumb rubber, cork, and no infill), field age, and temperature affect phthalate concentrations, turf-air exchange, and risk. Samples were analyzed for 31 phthalates and alternatives using a gas chromatography-mass spectrometry method. A total of 10 phthalates were detected and quantified among all turf fields, including 5 novel phthalates found in the air above the turf surface. A smaller indoor field had about 100 times greater air concentrations than outdoor air. Infill type did not influence air concentrations, but fields with cork infill had the lowest turf pore air levels. However, a field with no infill had the highest turf pore air concentrations, suggesting non-infill components as potential sources of phthalates. Field age did not impact concentrations. Despite an approximately 10°C difference in temperature, air and turf pore air concentrations remained consistent. Fugacity ratios and diffusive flux demonstrated that volatilization occurred during both warmer and cooler months, highlighting potential year-round exposure concerns. Worst-case exposure scenarios predicted no potential inhalation and dermal risk from phthalate exposure to people who use turf fields for recreational, professional, and occupational purposes regardless of the field characteristics.

4.05.P-Th136 Passive Sampling Versus Discrete Water, Sediment and Bivalve Sampling: Assessing the Relative Value for Regulatory Decision-Making

Damian Shea[1], Wenling Wang[2], Goran Bozinovic[3], Xin-Rui Xia[1], Xiang Kong[1] and Prahlad Jat[4] (1)Statera, (2)Yunnan University, (3)University of California San Diego (UC San Diego), (4)University of North Georgia

Monitoring of organic chemicals in the aquatic environment faces the challenges of episodic emissions, complex mixtures, transformation products, and chemicals present at trace concentrations. Chronic, long-term exposure to chemicals is nearly always the driver for both human and ecological risk assessments and regulatory decision-making. We have assessed the relative value of passive sampling, discrete water sampling, sediment sampling and bivalve biomonitoring for estimating the chronic exposure to hydrophilic and hydrophobic organic chemicals spanning a log KOW range of ~0 to 8. The chemicals included polycyclic aromatic hydrocarbons, current-use and legacy organochlorine pesticides, polychlorinated biphenyls, plasticizers, pharmaceuticals, consumer product chemicals, stimulants, steroid hormones, haloacetic acids, and fecal sterols. Using sites in San Diego Bay, USA, the composite integrative passive sampler (CIPS) was deployed repeatedly for one month deployments, discrete water samples were collected at the time of deployment and retrieval, and sediment and bivalve samples were collected at each CIPS site. Sample extracts were analyzed by multiple GCMS and LCMS methods. No single sampling matrix provided data for all detected chemicals but the CIPS passive sampler came very close, only missing some hydrophilic chemicals that were detected in the discrete water samples while the water sampling missed dozens of chemicals detected in the CIPS. The sediment and bivalves proved by far the worst at the detection of chemicals missing nearly all

hydrophilic chemicals and some of the hydrophobic chemicals as well. A summary of the advantages and disadvantages of each method will be provided including completeness, uncertainty and reliability of the data and the relative cost of each method. The challenges of translating the passive sampling data into decision-making information that is acceptable to regulatory agencies will be discussed.

4.05.P-Th137 Integrating Passive Sampling and In Vitro Bioassays To Enhance Water Quality Monitoring

Sophie Emberley-Korkmaz[1], Hugo Marchand[1], Niladri Basu[1] and Jessica Head[1] (1)McGill University

Monitoring water quality traditionally relies on collecting water samples and quantifying targeted contaminants using analytical chemistry. This approach provides valuable long-term trend data for known chemicals but does not readily detect unknown contaminants. It also does not provide information on the bioavailability of contaminants and how they could impact aquatic organisms. Simultaneously, New Approach Methods that support the 3R's, such as the RTgill-W1 cell line (OECD TG 249), are increasingly being employed in water quality monitoring. However, this assay has primarily been used to evaluate single chemicals with a focus on cytotoxicity, which fails to derive mechanistic information or capture environmentally relevant mixtures. Our overall aim is to develop approaches that combines passive sampling techniques with transcriptomic-based bioassays in RTgill-W1 and RTbrain cells and understand how these tools can be used together within risk assessment frameworks. Polar organic chemical integrated samplers (POCIS) and semi-permeable membrane devices (SPMDs) were deployed at four sites for one month each, over a five-month period within a suspected contaminated site near Montreal. Extracts are actively undergoing non-targeted analysis with gas- and liquid-chromatography mass spectrometry methods to explore temporal and spatial trends in contaminant data. Extracts are also being tested by exposing RTgill-W1 and RTbrain cells to a dilution series of each extract. Cytotoxic and transcriptomic responses are assessed. For each extract, we calculated an in vitro effect concentration 50% (EC50) based on two cell viability endpoints (metabolic activity and cell membrane integrity). EC50s ranged from 29.8% of extract dissolved in exposure media to 79.3%. Ongoing work will derive transcriptomic points of departure (tPODs) for each extract dilution series. The tPOD represents a benchmark dose where a concerted transcriptomic response is first detected. We hypothesize that tPODs will reveal further insights into disrupted biological pathways that align with certain chemical profiles. While this work is still underway, it demonstrates the potential for integrating passive sampling and in vitro bioassays to provide a more comprehensive picture of water quality, including evaluating the toxicity of complex contaminant mixtures and unknown toxicants.

4.05.P-Th138 Evaluating the Accuracy and Precision of Passive Sampling Devices for per- and Polyfluoroalkyl Substances (PFAS) Monitoring

Evelyn Rowan[1], Xiaoyu Xu[1] and James Beasley[1] (1)University of Georgia - Savannah River Ecology Laboratory

Per- and polyfluoroalkyl substances (PFAS) are an understudied class of stable, non-reactive compounds that require novel and innovative monitoring approaches. Grab sampling and active biomonitoring are widely employed methods for detecting target analytes. However, grab sampling often fails to capture the spatial and temporal heterogeneity of PFAS distributions, while active biomonitoring relies on biota that may exhibit inter- and intraindividual heterogeneity in PFAS accumulation and frequently requires lethal tissue collection. Passive

sampling devices (PSDs) are a novel monitoring method that alleviates these challenges while providing additional benefits, such as time-weighted average concentrations and reduced time and cost expenditures. We deployed four commercially available PFAS PSDs (DGT, PassiveX, POCIS, PFASsive) in surface water and sediments at three locations across the Savannah River Site (South Carolina, USA) for 21 days to determine which PSD most accurately represents localized PFAS contamination. We then deployed the most accurate PFAS PSD alongside fathead minnow (Pimephales promelas) and channel catfish (Ictalurus punctatus) to determine whether PFAS PSDs can replace active biomonitoring methods. Our initial evaluation demonstrated that PFASsive – an equilibrium-based PSD – was the most accurate PSD in surface water and porewater matrices, though surface water PFASsive devices generally performed better. Further, surface water PFASsive devices showed comparable or improved precision relative to grab samples and displayed minimal biases across PFAS functional groups and chain-lengths. Our findings support the use of PFASsive for global surface water PFAS monitoring. Our ongoing research comparing PFASsive and active biomonitoring methods will aid in evaluating PFASsive's potential as a surrogate for active biomonitoring.

Disclaimer/Disclosure: This research is based upon work supported by the DOE under Award Number DE-EM0005228 to the University of Georgia Research Foundation. Disclaimer – The views expressed herein do not necessarily reflect the views of the US Government, nor does reference to any commercial product imply endorsement.

4.05.P-Th139 Evaluating Passive Samplers for Enhanced per- and Polyfluoroalkyl Substances Source Fingerprinting in Ground and Porewater

Nicholas Hayman[1], Nicolas Sarracco[1], Jessica Carilli[1], Robert George[1], Mario Malfavon[1] and Claire Hauge-Rogers[2] (1)Naval Information Warfare Center Pacific, (2)San Diego State University Research Foundation

Per- and polyfluoroalkyl substances (PFAS) are ubiquitous environmental chemicals representing significant financial liability for remediation. Consequently, advanced monitoring techniques and tools are critically needed to enhance data quality and optimize source identification. This study evaluates the use of both kinetic and equilibrium passive samplers in groundwater monitoring wells and adjacent sediment porewater at a site with multiple potential PFAS sources. Sampling stations were selected along a gradient extending from suspected upland source zones to the nearshore. By comparing measurements from passive samplers against standard grab samples, this project assesses whether passive sampling enhances the detection of diverse PFAS, thereby facilitating more robust source-fingerprinting techniques. Previous source-identification efforts using grab samples at this site were unsuccessful due to low detection frequencies. Because some passive samplers utilize adsorptive materials to preconcentrate analytes, they generally improve the detection of trace-level PFAS, which is expected to strengthen fingerprinting analyses. While fingerprinting of PFAS has been successful using sophisticated non-targeted, high-resolution mass spectrometry (HRMS) techniques, those methods require highly specialized equipment and technicians and are expensive to use, making broad application unlikely. Passive sampling may offer a middle ground by improving fingerprinting compared to grab samples, without the cost and specialized knowledge neeeded for HRMS techniques. Improving the capacity of site managers to delineate PFAS sources at impacted sites will ultimately enhance remediation outcomes and ensure the equitable assignment of liability.

Disclaimer/Disclosure: The project was funded by the (U.S.) Navy Environmental Sustainability Development to Integration Program (Project 630)

4.05.P-Th140 Passive Sampler Assessment of Organic Pollutant Concentrations and Chemical Fluxes Above Shell Mounds Beneath Offshore Oil and Gas Platforms

Wenjian Lao[1], Dario Diehl[1], David Gillett[1] and Charles Wong[1] (1)Southern California Coast Water Research Project Authority

The decommissioning of offshore oil and gas platforms in Southern California requires evaluation of potential impacts on biotic assemblages associated with shell mounds beneath these structures. Due to the logistical challenges of directly sampling shell mound sediments, a passive sampling approach was employed to characterize baseline concentrations of organic pollutants and associated chemical fluxes in the overlying water column. In this study, polyethylene (PE) passive samplers were deployed to measure persistent organic pollutants (POPs), including polycyclic aromatic hydrocarbons (PAHs) and dichlorodiphenyltrichloroethane (DDT)-related compounds, in waters above shell mounds. Samplers were deployed at three depths relative to the shell mound surface (sediment–water interface, 5 m, and 10 m above the mound) beneath two offshore platforms and at a reference site characterized by natural sediments. The PE samplers were exposed for approximately one month. Freely dissolved contaminant concentrations in the water column were estimated using nonequilibrium corrections based on preloaded performance reference compounds (PRCs), and chemical fluxes were subsequently calculated. By comparing contaminant concentrations and fluxes between platform-associated shell mounds and the reference site, the accumulation potential of shell mounds was evaluated. The results provide critical baseline information for assessing contaminant remobilization, bioavailability, and potential ecological influence associated with shell mounds during platform decommissioning activities.

4.05.P-Th141 Investigating 161 PAHs in Water and Resident Aquatic Organisms From an Industrial Harbor Over Two Decades

Eric Luera[1], Lane Tidwell[1] and Kim Anderson[1] (1)Oregon State University

Dietary intake is the most common route of exposure for polycyclic aromatic hydrocarbons (PAHs). Signal crayfish are a common catch for recreational fishermen around the Portland Harbor and are also a regular food source for several communities, including the local Eastern European and Indigenous populations. Crayfish accumulate PAHs in their hepatopancreas due to low levels of Cytochrome P450, the primary PAH-metabolizing enzyme. Alkylated PAHs (APAHs) are more abundant than parent compounds in petroleum-contaminated sites and can be more bioactive. Most toxicological studies focus primarily on unsubstituted PAHs, potentially misrepresenting environmentally relevant mixtures. Low-density polyethylene passive sampling devices (PSDs) capture the bioavailable fraction of organic contaminants in their surroundings and provide a noninvasive alternative to biomonitoring. This project aims to develop a predictive model for PAH concentrations in crayfish viscera using PSDs by assessing temporal and spatial changes in PAHs/APAHs within and around Portland Harbor over the last two decades
In 2003, 2013, and 2023, PSDs and crayfish collection cages were co-deployed at several sites throughout the Willamette River, including within Portland Harbor. Crayfish viscera and PSDs were analyzed for 48 unsubstituted PAHs and 113 APAHs using a novel gas chromatography-tandem mass spectrometry method. The results of this study found that APAH concentrations were higher in crayfish viscera than parent

compounds, with APAHs comprising the majority of the top five most abundant PAHs in crayfish samples from each year. PAH profiles within the superfund site differed greatly across years, and PAH contributions from upriver sources are increasing each year as well. Previous iterations of this study found that PSDs can accurately predict PAHs found in crayfish. While model development is still ongoing, this study aims to expand the analyte list used for the model from 63 to 161 PAHs. Lastly, this study emphasizes that both parent and alkylated PAHs must be considered when developing risk assessments for crayfish consumption.

4.05.P-Th142 Investigating Fracking-Related PAH Exposure Over Concerns of Adverse Neonatal Health Outcomes in Foals

Eric Luera[1], Lane Tidwell[1] and Kim Anderson[1] (1)Oregon State University

Dysphagia is a disorder characterized by difficulty swallowing that can have anatomical or neurological causes. One Pennsylvania (PA) farm experienced frequent diagnoses of neurological dysphagia in foals, but a New York (NY) farm with the same owner, feed, and husbandry practices experienced no such cases. One notable difference between the two farms is that the PA location was within a mile of a fracking site. Polycyclic aromatic hydrocarbons (PAHs) are frequently detected near fracking sites and have demonstrated developmental and neurological effects. Alkylated PAHs (APAHs) are more abundant in petrogenic sources, like fracking sites, but are understudied compared to unsubstituted PAHs.
To determine if these dysphagic foal births were associated with gestational exposure to PAHs, passive sampling devices (PSDs) were deployed for a 21-month study period at both farms. Low-density polyethylene PSDs were used to sample air and drinking water sources. Additionally, breeding mares at both sites wore personal silicone PSDs on their halters. A novel analytical method was used to quantify 113 APAHs and 48 unsubstituted PAHs in all three PSD types. This study aims to compare PAH profiles between the two farms and between mares with and without dysphagic foals. We hypothesize that the proportion of APAHs to parent PAHs will be higher in the PA farm than in the NY farm, and that mares exposed to higher concentrations of PAHs/APAHs during gestation will exhibit an increased incidence of foal dysphagia. Before the installation of a water filtration system, PAH concentrations in the PA farm's drinking water exceeded those in the NY farm. After filtration, water concentrations in the PA farm decreased, more closely resembling the NY farm. Data collection for the personal PSDs worn by mares is still ongoing, but previous PSD studies have shown that individuals residing in the same household have very different exposure profiles. Mares may be exposed differently based on location preferences within the farm. Neurological and developmental risks from prolonged proximity to fracking sites are investigated in this study, using horses as a sentinel species.

4.05.P-Th143 Seasonal Distribution and Potential Bioavailability of Priority and Emerging PAHs in a Korean Freshwater System Using Linear Low-Density Polyethylene Passive Samplers

Hyeonju Jung[1], Jin-su Oh[1], Ye-won Song[1] and Gi Beum Kim[1] (1)Gyeongsang National University

Polycyclic aromatic hydrocarbons (PAHs) are hydrophobic organic contaminants that can enter aquatic environments through intentional and unintentional combustion emissions, traffic sources, urban runoff, and atmospheric deposition. Despite growing concerns regarding emerging PAHs (e-PAHs), including alkylated, nitrated, and halogenated PAHs, their bioavailability in aquatic environments is scarcely reported. Measuring

both bioavailable priority PAHs and e-PAHs can improve our understanding of their environmental behavior, sources, and ecological risks. Jinyang Lake, located in Jinju, Korea, serves as a drinking water source for approximately one million people and is connected to the downstream main channel of the Nam River, an important habitat for local wildlife. Because the surrounding region is characterized by a complex mixture of industrial, agricultural, and residential areas, assessing the potential mixture toxicity of PAHs is very important. This study aimed to (1) identify contamination patterns of freely dissolved priority PAHs and e-PAHs in the source water and connected river, (2) evaluate seasonal and site-specific variations, and (3) assess their mixture effects using water column toxic units (WCTUs) suggested by the USEPA. Novel linear low-density polyethylene (LLDPE) passive samplers were deployed for four weeks at seven sites across Jinyang Lake and the Nam River, and field surveys were conducted over four seasons from April 2025 to January 2026. Individual PAH profiles were dominated by low- and medium-molecular-weight PAHs. The freely dissolved concentrations (Cfree) of PAHs were affected by surrounding land uses and precipitation. The diverse e-PAHs provided additional insight into source apportionment. Including e-PAHs in the calculation of ∑WCTU reduced the underestimation in the assessment of potential biological effects. This study provides the first field evidence supporting the need to consider diverse e-PAHs in Jinyang Lake and the Nam River. The results may also provide baseline information for future ecological risk assessment and water management strategies.

Disclaimer/Disclosure: This work was supported by the Development of Technology for Impact Assessment and Management of HNS discharged from Marine Industrial Facilities of Korea Institute of Marine Science & Technology Promotion (KIMST) funded by the Ministry of Oceans and Fisheries, Korea [RS-2021-KS211535].

4.05.P-Th144 Connecting Environmental Exposures to Toxicology: Multi-Species Exposure Studies Using Silicone Wristbands Extracts

Sierra Smith[1], Javier Huayta ramirez[1] and Sakina Shadid[1] (1)Duke University

Silicone wristbands have emerged as passive sampling tools to monitor environmental contaminant exposures. They work by mimicking the skin, where SVOCs (semi volatile organic compounds) and VOCs (volatile organic compounds) can sorb onto the surface of the wristband and accumulate over time, providing time aggregated measures of chemical burden especially by dermal and inhalation routes of exposure. While exposure assessments give us insight into chemical burdens, the mere presence of chemicals does not guarantee toxicity. Exposing model organisms to silicone wristband extracts could therefore provide more toxicokinetic resolution and could capture toxicity caused through multiple mechanisms, allowing for a more holistic preliminary analysis of a chemical mixture. The current study used a novel, multi-species approach to investigate biological responses to wristband extracts focusing on neuro- and renal toxicity endpoints. Chemical data from each wristband was also gathered through non-targeted analysis using gas chromatography-mass spectrometry (GC-MS). Combining multi-species toxicity data with chemical data allowed for the identification of potential drivers of toxicity within each wristband extract.

4.05.P-Th145 Assessing Novel PAHs Emissions From Artificial Turf: Turf Characteristics' Impact on Occurrence, Flux Dynamics, and Implications for Human Exposure

Alison Clark[1], Kelly O'Malley[1], Lane Tidwell[1] and Kim Anderson[1] (1)Oregon State University Department of

Environmental and Molecular Toxicology

The use of artificial turf has raised health concerns in popular media and literature due to the volatilization of chemicals from turf, often focusing on the chemical content of the infill materials. Among these are polycyclic aromatic hydrocarbons, or PAHs, and their alkylated derivatives. Exposure to these chemicals has been linked to health effects such as inflammation, asthma, and certain cancers when exposed via inhalation. Data gaps on the impact of turf infill and other characteristics on off-gassed PAH presence currently exist. To address these gaps and to better understand potential risks of turf fields, low-density polyethylene passive samplers were deployed for one month in 2025 across ten artificial turf fields that varied in infill types, ages, ambient temperatures, and indoor versus outdoor settings. Samples were analyzed for 161 PAHs using GC/MS/MS. In total, sixty-two PAHs were detected, including over thirty novel PAHs not previously reported in artificial turf. All fields showed similar ranges of PAH detections. Diffusive flux patterns across all fields typically revealed that larger PAHs (3 or more rings) were actively volatilizing. Infill of artificial turf had no significant effect on observed PAH concentrations while crumb rubber infill contributed to the magnitude of PAH diffusive flux more so than other infill types. Indoor fields consistently had significantly elevated concentrations and greater levels of volatilization than outdoor fields. No significant relationship between field age or temperature was found. Contributions of both inhalation and dermal exposure pathways within total exposure were evaluated and revealed that the dermal uptake of most vapor-phase PAHs is low. Human health risk assessment predictions across athletic and occupational settings indicated little increased risk to health from the use of artificial turf fields; indoor fields predicted health outcomes were occasionally above levels of concern.

Disclaimer/Disclosure: Funding was provided by the National Institute of Environmental Health Sciences grant numbers T32ES007060, P42ES016465, and P30ES030287. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

4.05.P-Th146 The Spatiotemporal Dynamics of Vapor-Phase PAH Exposure: An Integration of Personal and Environmental Passive Sampling

Alison Clark[1], Lisa Bramer[2], Emily Bonner[1], Diana Rohlman[1], Lane Tidwell[1], Katrina Waters[2] and Kim Anderson[1] (1)Oregon State University Department of Environmental and Molecular Toxicology, (2)Pacific Northwest National Laboratory

The exposome is the sum of exposures that a person may encounter over a lifetime. Chemicals in outdoor air contribute to a person's exposome, particularly near their residences. An understanding of chemical movement in the air column after emission is needed to assess the impact of outdoor air on the exposome. This study combines repeated personal and environmental passive sampler data to investigate the relationship of personal exposure to outdoor air, and more specifically, how a persons' total polycyclic aromatic hydrocarbon (PAH) exposure is influenced by localized PAH sources. PAHs are common environmental contaminants. In 2022-2023, 46 participants in St. Helens, OR, wore silicone wristbands (WB) for one week every other month to collect personal exposure samples. A subset of participants (n=27) concurrently placed low-density polyethylene (LDPE) air samplers outside their homes to create paired data points. Ten community samplers were placed in public places in the same community. These samplers were returned monthly to the laboratory by mail and analyzed via gas chromatography tandem mass spectrometry (GC/MS/MS) for 64 parent and alkylated PAHs. Air equivalencies for silicone and LDPE were calculated to enable a direct comparison between the two sample types. Thirty-nine PAHs were detected in both samplers, 45 total in WB.

Concentrations in LDPE clustered by sample month rather than location. Monthly changes in LDPE PAH concentrations were not always reflected in the paired wristband, suggesting indoor air may have a higher influence on personal exposure than outdoor air. Interpolation by ordinary kriging suggested a uniform landscape even around known sources of PAHs, except an area near a legacy creosote contaminated site. LDPE samplers within 0.5 km of this site showed higher PAH concentrations over time than all other samplers. Human health risk assessment values such as hazard quotient and excess cancer risk were calculated for 22 PAHs. Wristband samplers near some observed PAH sources had higher concentrations; further analysis is being conducted to assess whether a correlation between outdoor source and personal exposure is present. Air concentrations from WB and LDPE were compared to health-based screening levels to identify potential health endpoints of concern for participants. Calculated values were much larger in WB than in LDPE, suggesting that the use of outdoor air in predicting health endpoints may underestimate risk.

Disclaimer/Disclosure: Funding for this research was provided by the National Institute of Environmental Health Sciences grant numbers T32ES007060, P42ES016465, P30ES030287. Two authors of this research disclose a financial interest in MyExposome, Inc. The terms of this arrangement have been reviewed and approved by OSU.

4.05.P-Th149 Calibration of Bird-Borne Passive Air Samplers Using Wind Speed for Assessing Exposure to Airborne Contaminants

Angela Lam[1], Anya Guo[1], Anaïs Kerric[2], Jonathan Verreault[2], Miriam Diamond[3] and Joseph Okeme[1]
(1)McMaster University, (2)University of Quebec in Montreal (UQAM), (3)University of Toronto

Bird-borne passive air samplers are important tools for assessing levels of contaminants in the environment relevant to birds' exposure and health. Previous studies using bird-borne passive air samplers are limited by challenges in calibrating samplers to estimate air concentrations based on mass loading of chemicals on samplers. We aim to address this gap by calibrating bird-borne passive air samplers using wind speed experienced by samplers, estimated from global positioning system (GPS) and weather station data. We found high wind speeds during the flight phase (14.3 m/s ± 17%) for three birds based on their GPS-acquired flight direction and ground speed. Based on these wind speeds, estimated uptake rates during flying (6.82×10^9 m^3/day ± 1%) caused equilibrium to be reached between the air and sampler for 21 semi-volatile organic compounds (SVOCs, e.g., brominated diphenyl ethers) measured previously on bird-borne passive air samplers. Wind speeds estimated from a weather station for resting periods were lower (3.38 m/s ± 47%) than wind speeds during flight periods. Assuming air concentration is constant across altitudes and birds experience at least one flight period where chemicals reach equilibrium, we hypothesize that bird-borne passive air samplers can be used as equilibrium samplers for air-borne contaminants. We estimated that the birds were exposed to concentrations of SVOCs ranging from 1.74×10^-3 pg/m^3 to 3.77×104 pg/m^3. Our method for estimating air concentrations will improve accuracy in assessing inhalation exposure to contaminants for birds, assisting in monitoring for chemical risks in the environment.

Beyond the Usual Suspects: Exploring Emerging Per- and Polyfluoroalkyl Substances in Uncommon Systems

4.06.T-02 Looking Through a New Lens: Exploring Contact Lenses As Passive Samplers of PFAS in Tear Fluid

Alyss McPherson[1] and Joseph Okeme[1] (1)McMaster University

Tear fluid is a promising but underexplored matrix for studying biomarkers of exposure to harmful compounds. Because tear fluid is a plasma filtrate and is also in contact with the air, it is uniquely able to capture both endogenous and exogenous compounds for simultaneous internal and external exposure monitoring. However, current methods for collecting tear fluid samples, Schirmer strips and capillary tubes, are limited by low sampling volumes, single time-point sampling, risk of ocular irritation, and the need for licensed optometrists. Daily disposable contact lenses are a possible alternative method for collecting tear fluid that allows participants to sample their own tear fluid from the comfort of home over the course of the entire day. Our lab group has previously demonstrated that daily disposable contact lenses can act as a "passive tear sampler" for biological compounds such as neurochemical markers and ingested compounds such as pharmaceuticals. In this study, we explore the sampling applications of contact lenses for measuring chemical exposures by characterizing the uptake kinetics of neutral and volatile per- and polyfluorinated alkyl substances (PFAS) onto contact lenses. We incubated contact lenses in simulated tear fluid spiked with PFAS standards and collected time point samples, which we analyzed with gas chromatography coupled to an Orbitrap mass spectrometer. We then constructed an uptake curve for each PFAS and derived uptake rates for linearly accumulating PFAS and tear fluid-contact lens partition coefficients (Ktear-lens) for equilibrating PFAS. We also compared uptake rates and Ktear-lens across the different PFAS species, hypothesizing that physical-chemical properties might influence uptake kinetics, particularly for equilibrating PFAS. By characterizing PFAS uptake onto contact lenses from tear fluid, we demonstrate how contact lenses can be applied as a novel tool for sampling and quantifying PFAS and other harmful compounds in the tear film.

Disclaimer/Disclosure: This research was funded by the McMaster University Department of Chemistry and Chemical Biology.

4.06.T-03 Maple Sugaring in a PFAS-Contaminated World: Challenges and Opportunities

Emily Sigman[1], Sara Nason[2], Joseph Orefice[3], Haoran Yang[4], Jasmine Jones[2], William Kessler[3], Priyankar Chand[2] and Raees Ahmad[2] (1)No Affiliation, (2)Connecticut Agricultural Experiment Station, (3)Yale School of the Environment, (4)Connecticut Agricultural Experiment Statiom

Maple sugaring is an important North American tradition with associated economic, cultural and environmental benefits. Per- and Polyfluroalkyl Substances (PFAS) are ubiquitous environmental contaminants that can be highly toxic at very low concentrations, and the risk posed by environmental PFAS contamination to maple sugarmakers is unclear. On one hand, PFAS are mobile within plants, and can enter the transpiration stream. Therefore, concentrated tree sap products such as maple syrup may contain concerning levels of PFAS, particularly if sap is obtained from highly contaminated sites. On the other hand, maple trees may select against PFAS uptake, or alternatively, PFAS in maple sap may not concentrate linearly during the syrup-making process, potentially volatilizing, sorbing to equipment, or filtering out alongside 'sugar sand' precipitates. We

investigated PFAS in maple syrup in a 2 phase project. In phase 1, we collected paired sap and soil samples in urban and rural areas of New England, USA. We included sites with histories of significant PFAS contamination, as well as control sites with no known history of PFAS contamination. We detected low levels of PFOA, PFBS and PFPeA in sap collected from sites with known histories of contamination, but detected almost no PFAS in the control-site sap. Interestingly, we did not find a correlation between soil and sap PFAS profiles, suggesting that upper horizon soils may not be acting as sites of PFAS transfer. In phase 2, we spiked PFAS-free sap with a mixture of PFAS and analyzed changes in concentrations under a variety of syrup-making scenarios. We compared reverse osmosis to boiling-only methods and tested different syrup filtering strategies. We found minimal impacts from reverse osmosis and mixed impacts from filtration. We also found consistent concentration of long-chain PFAS in the foam that forms during sap boiling. This data has important implications that invite future study.

Disclaimer/Disclosure: This work funded by a USDA ACER Access grant and by the Dartmouth Climate Collaborative.

4.06.T-04 Temporal Analysis of Sediments, a Reservoir for Unknown per- and Polyfluoroalkyl Substances

Esmee Belzer[1], Graham Peaslee[1], Thomas Sinkway[2] and John Bowden[2] (1)University of Notre Dame, (2)University of Florida

Per- and polyfluoroalkyl substances (PFAS) are a class of fluorinated chemicals which contain environmentally persistent, bioaccumulative, and toxic compounds. Sediments are potential reservoirs for legacy long-chain PFAS and some short-chain PFAS. Some studies assess historic PFAS contamination, but do not capture the full extent of PFAS contamination because analytical standards exist for only a small fraction of the more than 1.8 million existing PFAS. Total adsorbable organofluorine (TAOF) analysis is a powerful technique which does not require isotopically labelled PFAS standards (commonly needed for targeted PFAS analysis) and can be used to determine the organofluorine mass balance gap within a sample, ultimately investigating whether the scope of PFAS contamination within a region is fully captured when compared to traditional targeted methods. Results from TAOF analysis represent the upper boundary of PFAS contamination within a sample, as opposed to results for a small subset of PFAS via targeted analysis. In this study, 26 fractionated sediment cores and 13 surface sediment samples (approximately 150 samples total) were collected around Tampa Bay, Florida. Sediment core age and sedimentation rates were estimated by radioisotope event dating using Cs-137. Sediment samples underwent TAOF analysis via particle-induced gamma-ray emission (PIGE) spectroscopy using a 3 MV Pelletron accelerator at the University of Notre Dame, in addition to a targeted PFAS analysis of the same sediment fractions via liquid chromatography tandem mass spectrometry (LC-MS/MS). A large fluorine mass balance gap between analyses indicated the presence of unknown PFAS in sediments, which were not accounted for within the traditional targeted workflow. This study presents a novel analysis of temporal environmental TAOF and targeted PFAS measurements within a heavily urbanized region; the methodology herein could be implemented to better encapsulate the total PFAS concentrations in any freshwater or saltwater sediment system.

4.06.T-05 Investigation of Menstrual Blood as a PFAS Excretion Pathway From the

Human Body

Alyssa Wicks[1], Kate Hoffman[1] and Heather Stapleton[1] (1)Duke University

Menstrual blood is a mixture of blood and tissue shed from the uterine lining monthly by most women during their menstrual cycle. Some PFAS are known to bind tightly to proteins in blood serum and have long biological half-lives in the human body. Several studies have observed significantly lower serum PFAS levels in females, which has often been ascribed to loss of PFAS during menstruation. However, no study to date has analyzed menstrual blood for PFAS to assess the extent of excretion. In this exploratory study, we seek to confirm that PFAS are detectable in menstrual blood and investigate whether the PFAS profile in menstrual blood is similar to that of blood serum and whole blood.
To support this study, recruitment of 25 participants is ongoing, with each participant providing serum and whole blood samples via venipuncture and collecting three days of menstrual blood using a PFAS-free menstrual cup. Serum, whole blood, and menstrual blood samples will be analyzed for a total of 52 PFAS analytes using LC-MS/MS analysis. Results from an initial test participant have confirmed that PFAS are present in menstrual blood, with over 10 PFAS analytes detected, several of the which were also present in the serum samples. PFAS concentrations in menstrual blood were approximately one-third of those measured in serum. These preliminary findings motivate further evaluation of PFAS detection in menstrual blood and its relationship to other biological matrices and menstrual health characteristics. The following will be presented: method development for overcoming menstrual blood clotting during collection, detection and distributions of PFAS found in menstrual blood, and correlation analyses of PFAS measured in menstrual blood with serum and whole blood. Additional analyses will explore associations between detected PFAS and participant survey responses on their period characteristics.

4.06.T-06 Airborne but Undermeasured: Improving the Characterization of Neutral and Ionic PFAS in Atmospheric Samples

Ludovic Mayer[1], Chunjie Xia[1], Kevin Romanak[1] and Marta Venier[1] (1)Indiana University Bloomington

Per- and polyfluoroalkyl substances (PFAS) are persistent contaminants of concern that can undergo long-range atmospheric transport and contribute to contamination of remote and freshwater ecosystems. While atmospheric deposition has been recognized as an important pathway for PFAS delivery to remote and freshwater ecosystems, atmospheric measurements have historically focused on a limited subset of ionic PFAS. Neutral PFAS, including fluorotelomer alcohols, fluorotelomer acrylates, fluoroalkyl sulfonamides, and fluoroalkyl sulfonamidoethanols, remain a challenge as they are comparatively under characterized despite their volatility, precursor potential, and relevance to long-range atmospheric transport.

This study aims to develop and evaluate an integrated method for measuring atmospheric PFAS in both gas and particulate phases, from field sampling to laboratory extraction and instrumental analysis, with a particular focus on neutral PFAS. Method performance was assessed through sampling media selection, extraction efficiency, background contamination, compound recovery, and atmospheric breakthrough.

Active air sampling was selected to reduce uncertainty in concentration estimates and enable gas-particle partitioning assessment. Quartz and glass fiber filters were used for particle-associated PFAS and particle mass characterization, while polyurethane foam and XAD-2 resin were used to retain gas-phase compounds. Soxhlet

extraction and accelerated solvent extraction were compared for ionic and neutral PFAS. Both approaches efficiently extracted ionic PFAS; however, accelerated solvent extraction improved recovery of neutral PFAS. Atmospheric breakthrough was evaluated and determined that PFOS, PFDA, PFECHS, PFHpA, PFPeA, PFPrS, and some fluorotelomer alcohols were prone to breakthrough under the tested conditions, potentially leading to underestimation of atmospheric concentrations and gas-particle partitioning.

Overall, this study addresses a critical measurement gap in atmospheric PFAS research by improving characterization of neutral PFAS in air. Evaluating compound-specific recovery and breakthrough provides guidance for interpreting atmospheric PFAS data and designing more reliable sampling strategies. This work provides a foundation for more accurate and comparable atmospheric PFAS measurements, particularly for compounds that are difficult to capture using conventional air-sampling approaches.

Beyond the Usual Suspects: Exploring Emerging Per- and Polyfluoroalkyl Substances in Uncommon Systems

4.06.P-Tu210 Detection, Identification, and Quantification of Poly- and Perfluoroalkyl Substances (PFAS) in Soils Irrigated With Recycled Wastewater

Maya Rogalski[1], Tom Young[1], Haizhou Liu[2], Amir Verdi[3], Patricia Holden[4] and Michelle O'Malley[5] (1)Dept. of Civil and Env. Eng., University of California, Davis, Davis, CA, USA., (2)Chem. and Env. Eng. Dept., University of California, Riverside, Riverside, CA, USA., (3)Env. Sci. Dept., University of California, Riverside, Riverside, CA, USA., (4)Bren School of Env. Sci. and Man., University of California, Santa Barbara, Santa Barbara, CA, USA., (5)Dept. of Bioeng., University of California, Santa Barbara, Santa Barbara, CA, USA

The highly agricultural economy of California is increasingly under threat from water scarcity, motivating increased consideration of alternative water sources such as recycled wastewater. However, this strategy raises potential concerns related to the input of contaminants to the agricultural environment and food supply, especially for highly mobile and/or persistent compounds like per- and polyfluorinated alkyl substances (PFAS). This study aims to identify and quantify PFAS contamination in soils at an agricultural research site irrigated with reclaimed water for the past decades. A dual acid-base extraction technique was employed to comprehensively extract cationic, anionic, and zwitterionic PFAS. Liquid chromatography with quadrupole-time-of-flight mass spectrometry (LC-QTOF-MS) was then used to separate and quantify PFAS in both positive and negative ionization modes. Here we report targeted quantification for 43 common PFAS and non-target analysis of relevant PFAS. Initial quantification of 14 sites indicates ΣPFAS ranging from 19.15 ng g-1 to 72.72 ng g-1, dominated by PFCAs and PFSAs. Preliminary non-target analysis suggests novel detection of di-PFCAs in agricultural soils. These findings will inform the applicability of irrigation with reclaimed water with respect to resulting PFAS soil contamination.

4.06.P-Tu211 Total Fluorine as a Proxy for Total PFAS Loading to Aquatic Systems From Consumer and Personal Care Products

Heather Lord[1] and Tammy Chartrand[2] (1)ALS Laboratories, (2)ALS Global

The presence of PFAS in consumer products is a major driver of PFAS exposure to humans and the

environment, for locations where no obvious point source can be identified. In particular, cosmetics and personal care products have gained notoriety in recent years as significant sources of these exposures. Further, Muir and Miaz noted in 2021 [Env. Sci. Technol., 55, 9527] that "Direct emissions to water from wastewater treatment plants (WWTPs) are thought to be the main sources of [PFAS] to surface waters globally as a result of … use and disposal of products containing their precursors and residuals". PFAS is present in many consumer products, which during use may shed significant PFAS into wastewater, and at end of life are typically landfilled. Because landfill leachate is highly enriched in PFAS and is typically directed to WWTPs for disposal, these plants become the primary route for PFAS in consumer products to enter the aquatic environment.

The types of PFAS in consumer products present an additional challenge for aquatic risk assessments. The types of PFAS in these products are very different from those at typically PFAS impacted sites, few if any can be reported in currently available tests, and virtually none have published relative potency factors. In the environment, many of these PFAS convert into the PFAS that are monitored and do have published potency factors. Currently, the only practical way to cost-effectively evaluate the load of PFAS present in a commercial product is to test it by a process called Combustion Ion Chromatography (CIC) which can report the total amount of fluorine in a sample.

ALS Laboratories conducted an interlaboratory study in 2026 to evaluate the ability of four laboratories to accurately report total fluorine (TF) in six different cosmetic and personal care products. In this presentation we will describe the CIC analysis procedure, the results of our method standardization and interlaboratory evaluation, and how a TF result can be used as a proxy for total PFAS. We will discuss the method's strengths, limitations and potential application to human and ecotoxicological risk assessments for environments impacted by these types of products.

4.06.P-Tu212 Transfer of per- and Polyfluoroalkyl Substances From Aquatic Insects to Nearshore Spiders Using the Total Oxidizable Precursor Assay

John Fast[1] and Karen Kidd[1] (1)McMaster University

Wastewater treatment plants (WWTPs) release per- and polyfluoroalkyl substances (PFAS) in the final effluents and expose aquatic organisms in downstream reaches. Many regulatory methods focus on legacy PFAS and precursors, but the overall analyte list is orders of magnitude lower than the number of suspected PFAS in use. Larval aquatic insects have been shown to accumulate PFAS downstream of hotspots and point sources, and they are retained through metamorphosis and transferred to riparian predators during emergence events. However, efforts to assess risk to aquatic and riparian food webs may be underestimating the total PFAS exiting the river downstream of WWTPs by only using targeted analytical methods. The Total Oxidizable Precursor (TOP) assay can reveal hidden PFAS by breaking down unknown compounds in the presence of hydroxyl radicals at high temperatures, converting them to legacy carboxylic acids. The difference between the pre- and post-TOP values suggests the presence of unknown PFAS or precursors. All PFAS were measured using LC-MS of pre- (44 PFAS) and post-TOP (250 mM $K_2S_2O_8$ at pH > 12 and 85°C to achieve oxidation of the sample) were analyzed separately to allow for comparisons. A pilot study downstream of a WWTP on the Grand River, located in Southern Ontario, Canada, determined that upwards of 80 ng/g PFAS were found in downstream larvae and 20 ng/g in emergent adult caddisflies, while 60 ng/g of PFAS was detected in riparian spiders. The dominant PFAS present in all biota were carboxylic acids and sulfonic acids of chain lengths between 4-10 carbon atoms, and two precursors (6:2 fluorotelomer sulfonate and MeFOSAA, a

sulfonamidoacetic acid precursor) were detected in spiders. Two other sites impacted by WWTPs, one having potential input from an adjacent landfill, were sampled in 2025 to assess spatial patterns within the Grand River watershed as well as comparisons between different functional feeding groups and trophic positions. Analyzing legacy PFAS and precursors in tandem will directly address the underestimation of PFAS accumulation in aquatic invertebrates and transfer to terrestrial food webs through emergent adults. These data will improve our understanding of the risks that wastewater effluents pose to aquatic-riparian ecosystems by expanding the scope of detectable PFAS in both water and biota.

4.06.P-Tu213 Toxicokinetics of Agriculturally Relevant per- and Polyfluoroalkyl Substances in Dairy Goats Exposed Through Contaminated Vegetation and Water Scenarios

Helena Wheeler[1], Alonso Doria Manzur[1], Jennifer Guelfo[1] and Todd Anderson[1] (1)Texas Tech University

Per- and polyfluoroalkyl substances (PFAS) are environmentally persistent compounds which emerged over the past century as a product of commercial and industrial development. Recent research highlights PFAS as a contamination risk in agricultural settings where pathways of exposure may include impacted drinking water and feed. While studies link PFAS exposure to bioaccumulation in livestock, there is limited understanding of how the toxicokinetics of agriculturally relevant PFAS and their transfer to secondary animal products (e.g., milk) varies as a function of exposure source and PFAS chain-length. To that end, we validated analytical extraction methods capable of accurately detecting PFAS in goat tissues, quantified PFAS uptake and elimination associated with ingestion of impacted vegetation and water in dairy goats and developed predictive models to estimate time required for effective PFAS clearance. Lactating dairy goats were exposed to one of two treatments to represent PFAS-contaminated drinking water, and forage grown in PFAS-contaminated soils. Non-dosed lactating dairy goats served as controls. Following initial dosing, the goats were fed a non-dosed diet and provided clean water for four weeks. Twenty agriculturally relevant PFAS were used for the exposure including perfluoroalkyl carboxylic acids (PFCAs), perfluoroalkyl sulfonic acids (PFSAs), bis-perfluoroalkyl sulfonimides (Bis-FASIs), fluorotelomer sulfonates (FTS), and fluorotelomer carboxylic acids (FTCAs). PFAS uptake, residence time, and elimination rate were determined by quantifying PFAS concentrations in blood (collected weekly), urine (collected daily), milk (collected daily); liver, muscle, and mammary tissues were also analyzed after trial competition on day 28 using high performance liquid chromatography-mass spectrometry (HPLC-MS). Understanding the toxicokinetics associated with representative PFAS exposure in agricultural settings is necessary to inform effective mitigation strategies which maximize agricultural productivity, and protect animal, human, and environmental health.

4.06.P-Tu214 PFAS and Fluorinated Compounds From Stack Emission and Ambient Air

Mike Chang[1], Samuel Haddad[1] and Eric Fausett[2] (1)Agilent Technologies Inc., (2)Agilent Technologies, Inc.

PFAS as environmental hazard is often looked up in the water and solid samples e.g. drinking water, soil, biosolids and so on. However, volatile/neutral PFAS and other airborne fluorinated compounds in the air are often neglected in measurements due to lack of toxicity data or the availability of analytical tools to measure them accurately in complex matrices such as stack emission. In this presentation, an overview of analytical tools for both stack emissions and ambient air testing will be discussed for volatile/neutral PFAS and fluorinated

compounds.

4.06.P-Tu215 Long-Term Retention and Vertical Migration of PFAS in Biosolid-Amended Agricultural Soils: A 13-Year Field Study

Hlengilizwe Nyoni[1], Catherine Reardon[2], Nicole Durfee[2], Tamie L. Veith[3], Heather E. Preisendanz[4] and Odette Mina[1] (1)Institute of Energy and the Environment, The Pennsylvania State University, University Park, Pennsylvania, (2)USDA-ARS, Soil and Water Research Unit, Pendleton, Oregon, (3)USDA-ARS, Pasture Systems and Watershed Management Research Unit, University Park, Pennsylvania, (4)Department of Agricultural & Biological Engineering, The Pennsylvania State University, University Park, Pennsylvania & 5. Institute for Sustainable Agricultural, Food and Environmental Science, College of Agricultural Sciences, The Pennsylvania State University, University Park, Pennsylvania

Understanding the fate and transport of PFAS in agricultural soils requires linking its behavior to the long-term impacts of organic amendments. Municipal biosolids and livestock manure are the two primary sources of carbon inputs to agricultural soils and can serve as ongoing pathways for PFAS entry, with potential implications for groundwater quality and ecosystem health. PFAS contamination in croplands poses risks through transfer from soil to plants, animals, and ultimately humans. Despite growing concern, the long-term fate and vertical distribution of PFAS in organically amended soils remain poorly understood. To address this knowledge gap, soil archives collected in 2007, 2013, and 2019 from a well-characterized long-term carbon-input experiment at the USDA-ARS site in Pendleton, Oregon, were used to evaluate biosolids, manure, and control-amended soils sampled at different depths. PFAS (40 analytes) were measured using EPA Method 1633. Summed PFAS concentrations (∑PFAS) in biosolid-amended topsoil reached up to 70 ng/g, substantially higher than those observed in manure-amended and control soils (both below 2 ng/g). PFAS precursors, including N-MeFOSE, N-EtFOSE, and FOSAs, decreased over time, whereas long-chain PFACs (PFDA and PFTeDA) increased, indicating in situ biotransformation. PFAS concentrations in subsoil rose between 2013 and 2019, indicating slow downward migration. Statistical analyses further confirmed significant effects of both sampling year and soil depth on PFAS distribution. These findings demonstrate the persistence of PFAS in soils for more than a decade, with precursor transformation shifting profiles toward unregulated long-chain PFACs. Regulated PFAS such as PFOS and PFOA represented only a small fraction of the total burden, highlighting the need for comprehensive monitoring approaches. This study offers valuable insights for improving soil management practices, PFAS monitoring strategies, and regulatory frameworks governing the land application of biosolids.

4.06.P-Tu216 Diffuse but Detectable: PFAS in Low-Order Streams Without Known Point Sources in Central Maryland

Heather Delaplaine[1], Christopher Salice[1], Ryan Casey[1] and Joel Moore[1] (1)Towson University

Per- and polyfluoroalkyl substances (PFAS) commonly known as “forever chemicals” are a diverse class of synthetic chemicals widely used in industrial processes, consumer products, and in aqueous film-forming foams (AFFFs). They are increasingly recognized by scientific and regulatory communities as contaminants of concern for human health. However, uncertainties remain regarding the distribution and transport of PFAS across landscapes, particularly from non-point sources. To address this gap, this study measured PFAS in low-order streams across central Maryland. Surface water, sediment, and crayfish were collected from fifteen streams in the Baltimore metropolitan region across five land use categories: undeveloped, residential (served

by sewer), residential (served by septic), highway/commercial, and agricultural areas. Where possible, selected streams drained into drinking water reservoirs. Samples were analyzed for 40 PFAS analytes following methods described in EPA Method 1633A. Surface water ΣPFAS40 concentrations ranged from 6.5-63.6 ng/L and were highest at highway/commercial sites. Among the 13 detected compounds, short-chain perfluoroalkyl carboxylic acids (PFCAs) predominated. Stream sediment ΣPFAS40 concentrations ranged from 1.2-2.9 ng/g dry weight (dw) and were highest at residential areas served by septic systems. Of the 31 detected compounds, long-chain perfluoroalkyl sulfonic acids (PFSAs) were the dominant class. Crayfish tissue ΣPFAS40 concentrations ranged from 5.6-55.8 ng/g dw, with the highest levels observed in crayfish from streams draining residential septic and sewer land uses. Long-chained PFCAs were the most abundant among the 25 detected compounds. Notably, several surface water samples exceed the April 2024 EPA established drinking water criteria of 4 ng/L for PFOA and PFOS, suggesting that these streams are net sources of PFAS to drinking water reservoirs. These findings provide baseline data on PFAS contamination in low-order streams and the potential contribution of nonpoint sources to environmental and drinking water quality in central Maryland.

4.06.P-Tu217 Bioaccumulation and Depuration of Perfluorohexanoic Acid (PFHxA) in Eastern Oysters (Crassostrea virginica) and Florida Largemouth Bass (Micropterus salmoides) Under Environmentally Relevant Exposure

Jessica Donaldson[1], Shisbeth Tabora Sarmiento[1], Lauren Blackman[1], Arabella Hertelendy[1], Estrella Maldonado[1], John Bowden[1] and Joseph Bisesi[1] (1)University of Florida

Per- and polyfluoroalkyl substances (PFAS) are a large group of anthropogenic chemicals with over 9,000 substances classified under its umbrella. PFAS extremely mobile, persistent, and resistant to breakdown in the aquatic environment. Historically, research has focused on PFOA and PFOS, ultimately leading a substantial gap in understanding the toxicity profile of short-chain PFAS in exposed aquatic organisms. In addition to a focus on “legacy” PFAS, research has focused largely on the effects of PFAS in model organisms. Non-model, commercially, and environmentally important aquatic organisms are vital to assess potential PFAS toxicity to best protect these vulnerable populations. To address these data gaps, the current study aims to evaluate the bioaccumulation and depuration in eastern oysters (Crassostrea virginica) and Florida largemouth bass (Micropterus salmoides) following exposure to environmentally relevant concentrations of Perfluorohexanoic acid (PFHxA). Oysters were exposed to 2 ng/L, 20 ng/L, 200 ng/L, and 2000 ng/L of PFHxA via waterborne exposure for 28 days followed by a 28-day depuration period where no PFHxA was present. Bass were exposed to 10 ng/g, 100 ng/g, and 1000 ng/g of PFHxA via foodborne exposure for 28 days followed by a 14-day depuration period were no PFHxA was present. The entire soft tissue portion of the oysters were used for extraction as oysters are consumed whole allowing for assessment of potential human risk. For bass, plasma, gonads, liver, and muscle were sampled for PFHxA extraction to determine potential consumption, parental transfer, and bioaccumulation. Following spiking with isotope labeled internal standards, PFHxA was extracted from the oyster and bass tissue. PFHxA concentrations were quantified using UHPLC-MS/MS. For the oysters, measureable bioaccumulation occurred only for the highest concentration (2000 ng/L) which reach steady state by day 14, and was no detectable PFHxA by day 14 of the depuration. For the bass, analysis is ongoing; however, we hypothesize that bass will accumulate high concentrations of PFHxA with both depuration and accumulation increasing with PFHxA concentration. We predict PFHxA will still be present at low levels on day 42. The findings in the study will help in predicting potential human health risk associated with consuming PFHxA-exposed oysters and bass as well as potential ecological health risk.

4.06.P-Tu218 From Ultra Short to Long Chain PFAS: Characterization of Treatment Residual Matrices Before and After Electron Beam Irradiation

Macarena Rojo[1], Carolina Cuchimaque[1], Luciana Cappelini[1], Tilda Pendelton[2], John Vennekate[3] and Natalia Soares Quinete[1] (1)Florida International University, (2)James Madison University, (3)Jefferson Lab, Department of Energy

Per and polyfluoroalkyl substances (PFAS) are widely detected in complex environmental matrices that resist conventional water treatment methods. This study investigates ultra-short, short and long chain PFAS occurrence in foam fractionation (FF), membrane concentrate (MC), granular activated carbon (GAC), and leachate (LEA), and evaluates the effects of electron beam (e-beam) irradiation and pH on PFAS degradation and precursor transformation. Samples were adjusted to pH 4 and pH 12 and irradiated at doses of 250, 500, 750, and 1000 kGy, then diluted or processed by SPE following LC-MS/MS. A Total Oxidizable Precursor (TOP) assay was performed to evaluate oxidizable PFAS precursors and their conversion to terminal PFAAs in both non- irradiated and irradiated samples. PFAS detected in non-irradiated samples included ultra-short chain compounds such as trifluoroacetic acid (TFA) and perfluoromethanesulfonic acid (PFMeS), together with short and long chain PFCAs, PFSAs, FTCA and FTS. Distinct profiles were observed in the evaluated samples: Foam fractionation samples showed the highest PFAS concentrations, with 8:2 FTS (1.6 mg L^{-1}), PFHpA (1.1 mg L^{-1}), TFA (400 µg L-1), and 6:2 FTS (300 µg L-1) as the dominant compounds. Leachate samples were characterized by elevated concentrations of TFA (28 ppb) and PFMeS (9 µg L-1), together with 5:3 FTCA (7.2 µg L-1), PFBA (4.3 µg L-1), PFBS (4.3 µg L-1), PFHxA (2.6 µg L-1), PFPeA (1.8 µg L-1), and PFOA (1.3 µg L-1). Membrane concentrate showed a different PFAS composition, with TFA (15 µg L-1), PFOS (12 µg L-1), PFHxS (8 µg L-1), and 6:2 FTS (6 µg L-1) being the most abundant compounds. In contrast, exhausted GAC showed longer chain PFAS and fluorotelomer compounds, including PFOS (54 ng g^{-1}), PFOA (38 ng g^{-1}), 6:2 FTS (33 ng g^{-1}), PFHxS (25 ng g^{-1}), and PFHxA (23 ng g^{-1}). Analysis of irradiated samples and TOP assay products is ongoing and will provide information on PFAS degradation, precursor transformation, and the influence of pH and dose on e-beam treatment performance. Inclusion of ultra-short chain PFAS extends the evaluation beyond commonly monitored PFAS and provides a broader assessment of PFAS behavior in residual matrices. Results from this work will contribute to the development and optimization of treatment strategies for PFAS- impacted systems.

4.06.P-Tu219 How Regulation and International Trade Shift Global PFOA Emissions and Exposure

Judith Glienke[1] and Frank Wania[1] (1)University of Toronto Scarborough

Per- and polyfluoroalkyl substances (PFAS) are anthropogenic contaminants detected in people, wildlife, and the environment worldwide, also in regions far removed from any known production or use. Perfluorooctanoic acid (PFOA), one of the most extensively studied PFAS, has been subject to progressive regulatory restrictions. While major manufacturers in North America transitioned away from PFOA use in the early to mid-2000s, global restrictions under the Stockholm Convention did not come into place until 2019. A critical but underexplored consequence of regional phase-out policies is that they may not reduce global emissions so much as relocate them: as production and manufacturing shift toward jurisdictions with less stringent oversight, emissions may occur in lower-income and developing regions that often lack the monitoring infrastructure or regulatory capacity to respond.

International trade is the mechanism through which this displacement often operates. Production, use, and waste management — and their associated emissions — are geographically decoupled from the consumption that drives them, meaning that regulatory action in one part of the world can quietly export environmental harm to another. This study addresses that dynamic directly by combining an existing global PFOA emission inventory with a trade attribution framework to distinguish production-based from consumption-based emission allocations across world regions. Tracing PFOA emissions embodied in traded goods and waste streams via multi-regional input-output analysis, we quantify how much of each region's environmental burden is driven by domestic consumption versus outsourced through trade, and identify which regions disproportionately bear the environmental costs of others' consumption and regulatory choices.
By resolving consumption-based emission footprints across world regions and over the two decades of progressive PFOA regulation, this work will reveal the extent to which regional restrictions have shifted — rather than reduced — the global emission burden, with particular attention to developing regions and the southern hemisphere where PFAS monitoring capacity remains limited. In doing so, it makes the case that regional regulations, while locally beneficial, can produce inequitable global outcomes if not paired with international coordination — and provides a quantitative foundation for more geographically just chemical risk governance.

Developing New Methods in Chemistry Which can be Used to Assess Environmental Impacts

4.07.T-01 Integration of Advanced Chemometric Techniques To Evaluate Diagnostic Potential of Heterocyclic Aromatic Compounds

Nipuni N. Vitharana[1], Thor Halldorson[1], Aviva Gerring[1], Brett Paddock[1], Thane Tomy[1], Mike Dereviankin[2], Ifeoluwa Grace Idowu[3], Chris Marvin[4], A. T. Fisk[5], Paul Helm[6], C. E. Heuvel[7] and Gregg Tomy[1] (1)Centre for Oil and Gas Research and Development (COGRAD), Department of Chemistry, University of Manitoba, Winnipeg, MB R3T 2N2, (2)Dereviankin Consulting Inc, Alberta, (3)Chemistry Matters Inc., Calgary, Alberta, T2N 3P7, (4)Water Science and Technology Directorate, Environment and Climate Change Canada, Burlington, ON L7S 1A1, (5)School of the Environment, University of Windsor, 401 Sunset Avenue, Windsor, ON N9B 3P4, (6)Ministry of Environment Conservation and Parks, Toronto, Ontario, M7A 2E3, (7)Great Lakes Institute for Environmental Research (GLIER), University of Windsor, 401 Sunset Avenue, Windsor, ON N9B 3P4

Polycyclic aromatic compounds (PACs) are an important class of organic pollutants introduced into the environment through petrogenic, pyrogenic, and biogenic processes. This diverse family includes polycyclic aromatic hydrocarbons (PAHs), alkylated-PAHs (APAHs), halogenated-PAHs (HPAHs) and hetero-polycyclic aromatic compounds (HPACs). Two extraction and purification methods were developed and validated to analyse HPACs in sediment and fish muscle tissue samples. The concentrations of a comprehensive suite of 105 homocyclic and heterocyclic PACs were calculated in Lake Ontario sediment and Lake Erie fish samples to identify the source, fate, and behaviour of these compounds. Sediment samples were collected from Hamilton Harbour, Toronto Harbour, and nearby river mouth areas. A source fingerprinting study was conducted to assess the impact of coal-tar- and non-coal-tar-based materials on PAC pollution in Lake Ontario sediments. Multivariate analysis techniques, such as principal component analysis and uniform manifold approximation and projection, were used to identify potential sources of PACs. Uniform Manifold Approximation and

Projection provided a more detailed visualization, highlighting compositional differences between harbour sediments and non-harbour sites. Distinct clusters were observed among sediment samples and 14 reference materials in multidimensional data analysis of HPAC concentrations. Spatial distributions of PACs across four Lake Erie fish species were identified using hierarchical cluster and multivariate analyses. Unconstrained ordination approaches revealed distinct HPAC contamination profiles among nine fish species from Lake Erie, largely influenced by habitat and feeding ecology. Redundancy analysis identified fish length and habitat use as significant drivers of HPAC profiles. Habitat use was assessed using $\delta^{13}C$ and $\delta^{34}S$, whereas trophic position, determined from $\delta^{15}N$, showed little influence on HPAC profiles. The two studies demonstrated that HPACs exhibit more distinct and environmentally meaningful contamination patterns than homocyclic PACs. These findings underscore the importance of incorporating HPACs into routine environmental monitoring programs to improve the understanding of the source, fate, and behavior of PACs.

Disclaimer/Disclosure: This work was supported by a Natural Sciences and Engineering Research Council Discovery (NSERC) Grant to GTT (Grant number: RGPIN-2024-04947). NV was supported by a University of Manitoba Graduate Fellowship (UMGF).

4.07.T-02 Mixed-Mode Liquid Chromatography-Tandem Mass Spectrometry With Large-Volume Injection for per- and Polyfluorinated Substances Analysis and Total Oxidizable Precursor Assay Workflows

Charles Powley[1], Justice Woke[1], Jessica Anton[1], Chandana LakkaSandrum[1] and Jimmy Murillo-Gelvez[1]
(1)STRIDE Center for PFAS Solutions

Advances in liquid chromatography with tandem mass spectrometry (LC-MS/MS) have improved detection of per- and polyfluorinated substances (PFAS) at environmentally relevant concentrations, but important analytical gaps remain, particularly for ultrashort-chain PFAS, sensitivity-limited applications, and high-throughput workflows. This presentation describes a mixed-mode liquid chromatographic approach designed to expand PFAS coverage while improving sensitivity and reducing sample-preparation demands.

The method uses novel mixed-mode LC columns that combine reversed-phase and anion-exchange retention, together with large-volume injection (LVI) of mixed methanol/water samples up to 100 µL. An on-column focusing effect enables detection down to ~1 pg/mL or lower, including ultrashort-chain PFAS such as trifluoroacetic acid. For drinking water, groundwater, and surface water, this performance can eliminate the need for solid-phase extraction (SPE); when SPE is retained, LVI can further extend sensitivity to levels limited more by laboratory PFAS background than by instrument capability. Applications include rapid small-scale column tests (RSSCT), analyses affected by reduced mass spectral sensitivity, and environmental fate and transport studies.

An additional application under development is a scaled-down total oxidizable precursor (TOP) assay. Conventional TOP workflows typically require water sample volumes of 100 mL or more and SPE concentration, which can introduce analyte loss through breakthrough and co-precipitation in high-salt matrices. Using the LVI approach, TOP sample volume was reduced to 5 mL and SPE could often be avoided, improving precision and accuracy while reducing labor requirements. Overall, this approach supports broader PFAS coverage, lower practical detection limits, and more efficient analysis for environmental applications.

4.07.T-03 MS2X: A Machine Learning Ready Database for Mass Spectra-to-X

Diwen Yang[1], Xiaoyun Wang[1] and Hui Peng[1] (1)University of Toronto

Machine learning holds great promise for environmental chemistry and toxicology research. In particular, mass spectra have been increasingly used as input features for machine learning, bypassing structural information. However, it is widely recognized that the lack of high-quality training data is a major limitation of current mass spectra-based machine learning models. To address this challenge, we herein established an MS2X machine learning–ready database consisting of mass spectra for ~460,000 compounds and related chemistry and toxicity data.

To increase the chemical diversity of MS2X, we compiled a large chemical library of more than 460,000 compounds, including drug-like compounds, pharmaceuticals, ToxCast compounds, food additives, and natural products. MS/MS spectra for each compound were collected using Orbitrap high-resolution mass spectrometers under standardized conditions. In parallel, we used a high-throughput platform to collect over 3 million bioactivity data points against multiple human proteins, including estrogen receptor α, peroxisome proliferator-activated receptor γ, and WD40 repeat-containing protein 91. In addition, physicochemical properties for all compounds were calculated using quantum chemistry-based software. Collectively, MS2X is an integrated database containing MS/MS spectra, bioactivity data, and physicochemical properties for ~460,000 compounds. This database provides an unprecedented opportunity to advance and benchmark machine learning models for environmental chemistry and toxicology applications.

4.07.T-04 Quantum Dots Toxicity Assessment: Realistic Models, Integration of Fate and Use of Machine Learning To Unravel Complex Mechanisms

Audrey Moores[1], Aude Bechu[1], Subhasis Ghoshal[1], Saji George[1], Ke Xu[1] and Ziruo Liu[1] (1)McGill University

Cadmium containing quantum dots (QDs) are used as display color converters, yet gap remains in their hazard assessment. We addressed this gap by synthesizing CdSe/ZnS QDs bearing polymer coatings matching commercial ones.1 We then studied their environmental fate, cell toxicity,2 digestion,3 and alternatives assessment.4 QDs were stable at circumneutral pH, with no Cd dissolution after six months, while acidic conditions caused rapid dissolution, reaching complete Cd release. ZnS shells reduced Cd dissolution by 75%, and aggregation into approximately 100 nm structures suggested lower bioavailability. Liver cell assays showed that acid exposed QDs separated from dissolved ions were less toxic than pristine QDs, highlighting roles for ions, shells, and coatings. In intestinal epithelial cells, complete core shell polymer QDs were most toxic because core surface interactions enhanced uptake, lysosomal acidification, ion release, oxidative stress, and cell death. Simulated digestion transformed QDs through Zn shell dissolution, surface exchange, and stage dependent cytotoxicity. We also performed an alternatives assessment to compared Cd-based QDs with OLED, QLED, perovskite, or Q OLED substitutes.
To further address QD ecotoxicity in aquatic systems, we developed a Monte Carlo regression machine learning model trained on heterogeneous literature data for cadmium, indium, perovskite, and carbon based QDs exposed to light, pH, ionic strength, and natural organic matter (NOM). We complemented the model with Chlorella vulgaris assays using Cd, In, and Pb based QDs. Predictions reproduced reported effects of excitation wavelength, QD concentration, pH, and ionic strength, while revealing non linear responses difficult to extract from individual studies. NOM enhanced cell viability only at low concentrations. Light had a dual role,

supporting viability under some conditions but reversing this effect at higher intensity. The model identified 24 h and 72 h as reliable exposure windows, with weaker reliability beyond 72 h. Together, these studies show that realistic material design, transformation aware toxicology, alternatives assessment, and machine learning can unravel QD toxicity mechanisms and guide safer innovation.

1. Env. Sci. Nano 2024, 11, 4255-4265.
2. Chem. Res. Tox. 2022, 35, 9, 1457–1466.
3. ACS Appl. Nano Mater. 2021, 4, 8, 8417-8428.
4. ACS Sustainable Chem. Eng. 2022, 10, 7, 2294–2307

4.07.T-05 Combinatorial Synthesis and Protein Affinity Selection Mass Spectrometry Approach (CoSyER:ASMS) for Assessing Nuclear Receptor Activities of Phase II Sulfate Metabolites

Zhipeng Cheng[1], Pranav Nair[2] and Hui Peng[2] (1)Nankai University, (2)University of Toronto

Xenobiotics, including dietary components, chemical pollutants, pesticides, and pharmaceuticals often undergo biotransformation within the human body. These biotransformation pathways alter the bioactivity of xenobiotics in humans; however, traditional approaches are infeasible for systematically assessing the bioactivity of large numbers of metabolites. Herein, we recently developed CoSyER as a general, ultrahigh-throughput data generation approach for bioactivity assessment of hundreds of compound analogues within weeks, by integrating combinatorial synthesis with protein affinity selection mass spectrometry (AS-MS). The CoSyER:ASMS approach involves the synthesis of hundreds of compounds at nanomole scale via one-pot combinatorial reactions. The resulting crude reaction products are then directly subjected to AS-MS for receptor binding assessment, eliminating the need for laborious purification of individual products.
As proof of concept, we select sulfation, which is a common phase II pathway for xenobiotics. A total of 139 sulfate metabolites were synthesized from 222 ToxCast chemicals using an optimized one-pot combinatorial synthesis approach. Four nuclear receptors (PPARγ, PXR, ERRγ, and FXR) were selected for AS-MS analysis to evaluate binding activities, covering 1,444 binary interactions. A total of 29, 25, 0, and 3 sulfate metabolites were identified as potential ligands of PPARγ, PXR, ERRγ, and FXR, respectively. Triclosan sulfate and 1-hydroxypyrene sulfate were further synthesized, and their bioactivities were validated using an orthogonal fluorescence assay. This study highlights the broad nuclear receptor binding activities of phase II sulfate metabolites by applying the high-throughput CoSyER:ASMS approach.

4.07.T-06 Exploring Digestion Methods for Insoluble Manganese in Preparation for Electrochemical Detection in Drinking Water

Kayla Elliott[1], Sarah Jane Payne[1] and Zhe She[1] (1)Queen's University

Exposure to high-levels of manganese (Mn) in drinking water have shown to have negative neurological effects on children, representing a critical public health concern prompting new water quality guidelines and regulations. Although treatment may be in place, trace levels of Mn leaving the water treatment plant can accumulate within the distribution system as reservoirs and can be released back into the bulk drinking water at levels that could exceed Health Canada’s maximum allowable concentration for total Mn (soluble and insoluble

species).
The traditional gold-standard spectroscopic techniques for Mn monitoring are not practicable for on-site detection due to their size, cost and operational difficulties. In addition, they require sample pre-treatment with hot concentrated acid to convert oxides into dissolved species. Bench-top colorimetric methods are also challenging to use as they have issues with accuracy and difficult to handle chemicals. Electrochemical methods, which are promising for on-site monitoring due to their low cost and portability are limited to the measurement of dissolved species. Thus, there is critical need to develop a new electrochemical method that can offer the advantage of real-time measurement and that can detect total Mn in drinking water.
This work explores digestion protocols for insoluble MnO2 using "green chemistry" reducing agents to prepare drinking water samples for the electrochemical detection of Mn. The impact of different conditions including solution pH, Mn concentration, digestion time and the presence of common drinking water contaminants are explored. The proposed methods are simple, reproducible and safe for routine use in the field, eliminating the need of hot concentrated acid. The ability to quantitatively detect total Mn on-site and will ensure that the drinking water reaching consumers' taps achieves the same standards as it did when leaving the treatment plants, thereby reducing the risk for negative health effects.

Developing New Methods in Chemistry Which can be Used to Assess Environmental Impacts

4.07.P-Tu139 Ultra-Short-Chain and Short-Chain PFAS Analysis in Drinking Water Using LC-MS/MS With Automated Sample Preparation

Om Shrestha[1], Logan Miller[1], Risa Suzuki[1], Tiffany Linden[1], Todd Anderson[2] and Evelyn Wang[1] (1)Shimadzu, (2)ePrep

Ultra-short-chain per- and polyfluoroalkyl substances (PFAS; C1–C4) present significant analytical challenges due to their low molecular weight, high polarity, poor chromatographic retention, and susceptibility to laboratory background contamination. While LC–MS/MS methods for short- and long-chain PFAS are well established, reliable analysis of ultra-short-chain PFAS in drinking water remains limited. This study presents a LC–MS/MS method with automated sample preparation for targeted quantification of ultra-short-chain PFAS in drinking water. This workflow enables reproducible quantification of C1–C4 PFAS at low-ppt levels and provides a practical solution for routine monitoring of these highly mobile and persistent contaminants in drinking water. Targeted analytes included TFSI, TFA, TFMS, PFPrA, PFEtS, PFBA, PFPrS, and PFBS with ^{13}C-labeled TFA as an internal standard. Samples and calibrants were prepared using an automated ePrep extraction system equipped with the PFAS free accessories. Chromatographic separation was completed in 8 minutes on a polar-embedded IBD column with a delay column to improve retention and minimize background interference. Analysis was performed on a Shimadzu LCMS-8065XE triple quadrupole system in multiple reaction monitoring, negative ion mode. Drinking water from seven local tap sources was spiked at three concentrations, with at least seven replicates per level, to evaluate spike recovery and method robustness. Calibration curves for seven targeted ultra-short-chain PFAS were linear over 0.01–1.00 ng/mL ($R^2 > 0.99$), with spike recoveries of 70–130%, using ^{13}C-labeled TFA (m/z 115 > 70) as an internal standard. Different stationary phases, including IBD, C18, and HILIC, were evaluated for both the analytical and delay columns, with the IBD column providing optimal retention and robustness. Seven-replicate calibration studies showed

%RSDs below 20% for all analytes. TFA (m/z 113 > 69) eluted at 1.3 min, and PFBS (m/z 298.9 > 80) eluted last at 2.7 min, with a total run time of 8 minutes. Samples and standards were prepared using the automated ePrep ONE sample preparation workstation. TFA was detected in five of seven local tap water sources at concentrations ranges from 0.5–1.5 ng/mL. Automated sample preparation combined with LC–MS/MS in MRM enabled selective, sensitive, and high-throughput quantification at low-ppt levels.

Disclaimer/Disclosure: For Research Use Only. Not for use in diagnostic procedures.

4.07.P-Tu140 Direct Injection Analysis of Ultra-Short Chain PFAS in Landfill Groundwater via Altura Column Chemistry and LC-MS/MS

Sydney Brady[1], Emily Parry[2] and Ivan Huang[2] (1)Agilent Technologies Inc., (2)Agilent Technologies

The increasing detection of ultra-short-chain per- and polyfluoroalkyl substances (PFAS) in environmental waters has highlighted the necessity for analytical methods capable of sensitively and reliably quantifying them. Ultra-short-chain PFAS such as trifluoroacetic acid (TFA) and Difluoroacetic acid (DFA) exhibit minimal retention on conventional C18 columns, necessitating specialized stationary phases, optimized mobile-phase conditions, and strict contamination control. This study evaluates the performance of the new mixed mode Altura Poroshell 120 PFAS Column coupled with an Agilent 1290 Infinity III LC and 6495D LC/TQ for the analysis of ultra-short chain PFAS in synthetic water matrices and landfill groundwater.

The three aqueous matrices examined were reverse osmosis (RO) water for calibration, synthetic high-ionic strength water to challenge method robustness, and groundwater collected during routine landfill monitoring. Synthetic matrices supported retention-time and recovery experiments, while groundwater results were compared with matched EPA Method1633A extractions generated by an external collaborator. Samples were vortexed, centrifuged, and fortified with two isotopically labeled internal standards prior to analysisThe method was optimized specifically to improve the retention and detection of early-eluting short-chain PFAS.

Retention times in synthetic high-ionic-strength water shifted slightly forward relative to RO standards, with the largest shift of 0.1 min for PFPrA. Groundwater samples showed retention times consistent with RO standards. Spike-recovery experiments demonstrated recoveries between 70–130% for most compounds, with acceptable precision. DFA exhibited matrix suppression, likely resolvable with a labeled analogue, while elevated TFA reflected variable environmental contamination in a mixed-use laboratory. Groundwater samples from seven landfills demonstrated frequent occurrence of ultra-short-chain PFAS; TFA was detected in all sites tested, followed by PFPrA, PFMeS, DFA, and PFBA. Comparison of PFBA concentrations between the direct-injection method and EPA Method1633A extractions yielded a trendline slope of 0.84, indicating agreement between the two approaches over the evaluated range.

Overall, the Altura PFAS Column provides robust retention, sensitive detection, and reliable quantitation of ultra-short-chain PFAS in complex environmental waters.

4.07.P-Tu141 ChiralRTlib: A Machine Learning-Ready Database for Chiral Separation Prediction With Standardized Negative Data

Xiaoyun Wang[1] and Hui Peng[1] (1)University of Toronto

Enantioselective toxicity and biotransformation of chemical contaminants have long been important topics in environmental chemistry. However, chiral separation remains technically challenging and largely empirical, limiting enantiomer-specific analysis of many environmental contaminants. Machine learning holds a great promise for guiding chiral separation, but its development has been constrained by the lack of high-quality datasets with well-defined negative data. Here we report ChiralRTlib, a machine-learning-ready dataset comprising 12,642 enantiomer pairs measured under standardized conditions across four commonly used chiral stationary phases. We further developed ChiralCP, a Chemprop-based graph neural network augmented with chirality-related descriptors to predict whether a compound can be separated on a given chiral column. ChiralCP showed robust performance across all four chiral columns and outperformed baseline models. Notably, model performance was strongly affected by the composition of negative data, with intermediate-similarity negatives giving the strongest out-of-distribution generalization. Together, ChiralRTlib and ChiralCP provide an open-source machine-learning toolbox to support enantiomer-specific analysis and environmental research on chiral chemical contaminants.

4.07.P-Tu142 Nuclear Receptor Activity Assessment of ToxCast Compounds at the Isomer-Level

Simeng Li[1] and Hui Peng[2] (1)University of Toronto; Chinese Academy of Agricultural Sciences (CAAS), (2)University of Toronto

Many environmental chemicals, such as pesticides and pharmaceuticals, contain chiral centers or exist as structural isomers, and their biological effects can depend on isomer-specific recognition by molecular targets. Nuclear receptors (NRs) are ligand-regulated transcription factors with defined ligand-binding domains that mediate pathways related to xenobiotic sensing, metabolism, and endocrine regulation. ~5,000 compounds have been comprehensively assessed for their nuclear receptor activities in the past decade, through the ToxCast program. However, their activities remain unknown at the isomer level, partly due to the lack of authentic standards for isomers.

To address this gap, we collected 991 compounds from the ToxCast library, including pesticides, pharmaceuticals, and other environmentally chemicals, and screened them against 24 human NRs using affinity selection mass spectrometry (AS-MS). Bioactive ligands enriched by AS-MS were further separated using chiral chromatography to assess enantioselective receptor binding. Representative ligands were purified and evaluated using orthogonal validation assays to confirm isomer-specific differences in NR binding or activity. Overall, this study provides an efficient strategy for identifying isomer-specific receptor binding activities and highlights widespread enantioselective activities.

4.07.P-Tu143 Location Matters: Metals Distribution in Canadian West Coast Roadside Blackberries

Matt Dodd[1] and Steve Grundy[1] (1)Royal Roads University

The Himalayan blackberry is a very robust perennial invasive plant that is well established in the Pacific

Northwest and is generally found in disturbed areas including forest edges, urban parks, along trails, roadsides, and riparian areas. The collection of blackberries in the late summer from plants growing along easily accessible roadways is common. Vehicular traffic and other anthropogenic activities can introduce metals (e.g., arsenic, cadmium, lead) into roadside soils and vegetation. Elevated levels of both essential (e.g., copper, zinc) and toxic metals (e.g., cadmium, lead) can impact human health through uptake into the food chain. Soil and blackberry samples collected from roadsides in Victoria and Vancouver, two major cities on the west coast of Canada were analyzed for various metals by XRF and ICP-MS. Arsenic, lead, and zinc concentrations in soil samples collected from high traffic corridors were relatively elevated compared to lower traffic areas while other metals such as barium, copper, chromium, iron, and nickel did not show discernible differences among the locations. Arsenic and lead concentrations in blackberry samples from the high traffic corridors were much higher compared to the low traffic areas. To further assess the potential impact of traffic and other land use activities, the study was expanded to include two less populated islands on the west coast (Salt Spring Island and Thesis Island). Metal distribution in soil and blackberry samples from the four study areas will be presented. Data from the correlation and principal component analyses used to explore the inter-relationship between metal concentrations in the soils, blackberries, traffic volume and surrounding land use will be presented. Mobility ratios (concentration in blackberries/concentration in soil) used to assess the bioaccumulation potential for each metal will also be presented. The soil data will be compared to existing data for the other Canadian cities and a meta-analysis including the potential human health risk associated with consuming the blackberries will be conducted based on Health Canada human health risk assessment guidelines. Finally recommendations for limiting exposure to contaminated blackberries and a strategy for effectively presenting this information to the public will be provided.

4.07.P-Tu144 Using Newly Developed Analytical Methods To Quantify Polycyclic Aromatic Hydrocarbons (PAHs) in Deep-Sea Crustaceans

Brian Shaddrix[1], Emily Pisarski[1], Marie DeLorenzo[2], Sydney McDermott[3] and Craig McClain[3] (1)National Centers for Coastal Ocean Science (NCCOS), (2)National Oceanic and Atmospheric Administration (NOAA), (3)University of Louisiana, Lafayette

Authors: Brian S. Shaddrix, Emily C. Pisarski, Marie DeLorenzo, Sydney McDermott, Craig McClain

Session: Developing New Methods in Chemistry Which can be Used to Assess Environmental Impacts

Polycyclic aromatic hydrocarbons (PAHs) are a class of organic contaminants that are widespread in the environment due to natural sources and human-related activities. They are persistent in the environment, toxic, and are highly lipid-soluble. The presence of PAHs in marine environments are often related to oil spills. Data are limited regarding chemical exposure and metabolism of PAHs in deep-sea benthic communities. The 2010 Deepwater Horizon oil spill event prompted the need to assess the impact of oil exposure near the wellhead on benthic organisms, including deep-sea crabs and isopods. Several methods currently exist for analyzing PAHs in other matrices (sediment, water, fish tissue), but crustaceans contain additional matrix interferences (e.g., high lipid content, pigments) that may not be eliminated through traditional analytical methods, causing chromatographical and recovery issues, impacting the ability to provide accurate results. For this study, a new analytical method was developed to extract and analyze PAHs in deep-sea marine crustaceans collected near the wellhead, specifically crabs and isopods. In this laboratory exercise, the hepatopancreas (crabs only) and

carapace tissue were targeted for PAH analysis. Pressurized fluid extraction was used along with gel permeation chromatography, followed by solid phase extraction. Samples were analyzed using gas chromatograph mass spectrometry for 50 parent and alkylated PAHs. Quality assurance and quality control (QA/QC) measures, including reagent blanks, reagent spikes, and matrix spikes were performed to assess method recovery. Preliminary QA/QC results in the reagent spikes, for all analytes, yielded average percent recovery ranging from 88% - 111% and % RSD ranging from 0% - 12%. Matrix spike recoveries ranged from 90% - 111% and % RSD ranged from 1% - 9%. The one exception was carbazole with percent recoveries ranging from 145% - 152%. Results indicate that this new analytical method provides a robust and reliable method for analyzing PAHs in marine crustaceans that will support assessments of injuries and recovery trajectories in deep-sea habitats.

4.07.P-Tu145 Direct Injection UPLC-MS/MS for Multi-Residue Analysis of Pharmaceuticals, Personal Care Products (PPCPs) and Pesticides in Water

Alex Birsan[1], Kari Organtini[1], Doug Stevens[1], Lindsay Hatch[1] and Naren Meruva[1] (1)Waters Corporation

A comprehensive analytical approach was developed to quantify more than 190 pharmaceuticals, personal care products (PPCPs), pesticides, and associated transformation products in drinking and surface waters using a direct aqueous injection, multi-residue UPLC-MS/MS method. The workflow was developed to address evolving European Union (EU) Water Framework and Drinking Water Directives, including Watch List requirements, which continue to expand the scope of regulated and monitored contaminants. Although the method was initially developed to address EU regulatory priorities, its broad analyte coverage and direct injection workflow are equally adaptable to emerging monitoring needs and contaminant surveillance efforts in the Americas including the reduced use of extraction solvents.

Method performance was assessed using the ACQUITY™ Premier System coupled to a Xevo™ TQ Absolute tandem quadrupole mass spectrometer with electrospray ionization (ESI). Three representative water matrices including tap water, surface water, and bottled mineral water were fortified at 10, 25, and 125 ng/L, with six replicates per level. Across all analytes, trueness and precision were evaluated to characterize robustness in both simple and complex matrices. In river water, the most challenging matrix, mean trueness was 92%, with individual values ranging from 57% to 131% across spike levels. The mean relative standard deviation (RSD) for trueness was 5%, and 99% of all matrix level combinations exhibited RSD values below 20%.

These results demonstrate that the method delivers reliable quantification across a broad suite of emerging contaminants and is suitable for use in monitoring programs that require high analytical confidence.

Developing New Methods in Chemistry Which can be Used to Assess Environmental Impacts

4.07.V-01 A 3D-Printed Extraction Platform for Pharmaceutical Analysis in Environmental Waters by ESI-HPLC-MS/MS

Veronica Rodriguez-Saldana[1], César Castro-García[1], Jennifer M. Luna-Díaz[1], Rogelio Rodríguez-Maese[1] and

Luz O. Leal-Quezada[1] (1)Center for Research in Advanced Materials, S.C. (CIMAV)

The emergence of additive manufacturing has opened new possibilities for the development of low-cost, customizable, and sustainable tools for analytical chemistry. Despite its growing adoption in laboratory applications, the use of three-dimensional (3D) printing for environmental sample preparation remains relatively underexplored. In this study, a reusable 3D-printed extraction device coupled with electrospray ionization high-performance liquid chromatography tandem mass spectrometry (ESI-HPLC-MS/MS) was developed for the determination of ibuprofen, paracetamol, and diclofenac in environmental waters. The extraction platform was designed to provide an efficient and environmentally conscious alternative to conventional sample preparation approaches while maintaining high analytical performance. Following optimization and validation, the method demonstrated excellent linearity ($R^2 > 0.996$), recoveries ranging from 96 to 103%, and low matrix effects (<17%). Limits of detection ranged from 0.002 to 0.041 μg L^{-1}, while intra- and inter-day precision remained below 10%. The 3D-printed device maintained consistent extraction performance for up to ten reuse cycles, highlighting its robustness and potential for routine applications. In addition, chromatographic separation was achieved in less than 7 min using only 4 mL of mobile phase per analysis. Assessment of the method's environmental sustainability using the AGREE metric resulted in a score of 0.56, demonstrating its alignment with green analytical chemistry principles. Application to environmental water samples confirmed the suitability of the proposed platform for trace-level pharmaceutical monitoring. These findings demonstrate how additive manufacturing can be successfully integrated into analytical workflows to enhance sustainability, reduce operational costs, and expand the accessibility of advanced environmental monitoring technologies.

Disclaimer/Disclosure: This project was supported by Centro de Investigación en Materiales Avanzados, S.C. (CIMAV) and funded by the Secretaría de Ciencia, Humanidades, Tecnología e Innovación (SECIHTI) and the Fondo Estatal de Ciencia, Tecnología e Innovación of Gobierno del Estado de Chihuahua.

Drop by Drop: Natural and Anthropogenic Drinking-Water Contaminant Exposures and Human Health Risk

4.08.P-We025 A Thyroid Hormone Mimetic in Disinfected Water: Phenotypic, Multi-Omics, and Molecular Docking Evidence

Tongtong Xiang[1] (1)Division of Analytical and Environmental Toxicology, Department of Laboratory Medicine and Pathology, Faculty of Medicine and Dentistry, University of Alberta, Edmonton, T6G 2G3, Canada.

BACKGROUND: Iodine plays a dual role at the water–health interface. While essential for thyroid function, it also forms reactive iodinated disinfection byproducts (DBPs) during drinking water treatment, posing overlooked endocrine risks. Iodotyrosine-derived DBPs resemble thyroid hormones (THs) and may represent overlooked hormone mimetic contaminants in drinking water.

OBJECTIVES: Here, we tested whether 3,5-diiodotyrosyl-alanine (DIYA), a drinking water relevant iodotyrosine-derived DBP, acts as a TH mimetic.

METHODS: Using zebrafish, integrated transcriptomic and proteomic analyses, and molecular docking, we investigated the TH-like developmental phenotypes, mechanistic reprogramming, and thyroid hormone receptor (TR) binding potential induced by DIYA.

RESULTS: DIYA induces a typical coordinated TH-mediated syndrome, including delayed hatching, altered pigmentation (iridophore enhancement and melanophore/xanthophore suppression), craniofacial and axial skeletal defects, impaired swim bladder inflation, tachycardia, locomotor suppression, and hepatic dysfunction (reduced liver size, diminished fabp10a fluorescence, and decreased alkaline phosphatase activity). Additionally, biliverdin accumulation emerged as a novel marker of TH-like phenotypic response. Multi-omics reprogramming converges on TH-associated pathways (retinol metabolism, phototransduction, PPAR signaling, and steroid/tyrosine metabolism), collectively supporting the emergence of TH-like phenotypes. They further reveal coordinated perturbation of key hypothalamic–pituitary–thyroid (HPT) axis genes (thraa, thrb, dio3b, slc5a5, duox, slc16a10), providing a mechanistic basis for the observed phenotypic spectrum. Molecular docking shows that DIYA is accommodated within the ligand binding domains of TRα and TRβ, with conserved interactions and affinities comparable to 3,5,3′-triiodo-L-thyronine (T3) and 3,5,3',5'-tetraiodothyronine (T4), supporting direct receptor engagement.

DISCUSSION: The representative iodotyrosine-derived DBP, DIYA, is a previously unrecognized TH mimetics formed during water disinfection, linking disinfection chemistry to endocrine disruption and prompting re-evaluation of iodinated DBPs in risk assessment.

Disclaimer/Disclosure: This study was supported by grants from the National Natural Science Foundation of China. The authors thank the China Scholarship Council, Alberta Innovates, the Canada Research Chairs Program, and the Natural Sciences and Engineering Research Council of Canada.

4.08.P-We029 Cumulative Risk Assessment: Per- and Polyfluoroalkyl Substances (PFAS) in Montana's Rural and Developing-Area Private Wells

Tess Sobolewski[1], Paul Bradley[2], Kelly Smalling[2], Margaret Eggers[3], Kristin Romanok[2], Molly Schreiner[2], James Gray[2], W. Adam Sigler[3] and Robert Walker[3] (1)Enspired Solutions, (2)USGS, (3)Montana State University

Exposure to per- and polyfluoroalkyl substances (PFAS) through drinking water is a global concern, but information on drinking water PFAS exposures in private well dependent communities remains limited. PFAS tap water sampling was conducted in three southwestern Montana counties from 59 private, well dependent residences. Analysis employing a recently developed, analytically rigorous protocol (minimum detection limit range: 0.2 – 1.0 ng/L for 6 regulated PFAS), detected at least one PFAS in 53% (31/59) of wells. Twelve PFAS were observed at least once with PFOS, PFOA, PFBS, PFHxS, FOSA, PFHpA, and PFHxA observed most frequently. The number of individual PFAS observed in a single well ranged from 0 to 7 with cumulative concentrations (sum of PFAS detected) ranging from 0 to 22.2 ng/L. A greater number of compounds were generally detected in shallower wells and on smaller property sizes, consistent with higher prevalence in younger (shallower) groundwater in areas with higher intensity land use. These findings document the presence of PFAS in private-well drinking water in rural and minimally developed areas and demonstrate the critical importance of employing newer PFAS analytical methods with detection limits below federal drinking water

standards to assess corresponding drinking water human health risk more accurately.

Disclaimer/Disclosure: This research was funded in part by the USGS Ecosystems Mission Area, Environmental Health Program. Additional support came from the NSF EPSCoR Cooperative Agreement OIA-1757351 and the Montana Water Center (MWC) USGS Water Research Act, section 104b.

4.08.P-We030 Non-Targeted Omics Approach to Highlighting Potential Chemical Drivers of Kidney Disease of Unknown Etiology in Sri Lanka

Fiona Quin Zabel[1], Penny Vlahos[1], Adam Graichen[1], Shuchi Anand[2], Andrew Roberts[1], Xue Yu[3], Ishara Athauda[4], Dhananjalee Mahalekam[4] and Maria Montez-Rath[3] (1)University of Connecticut, (2)University of California: Davis, (3)Stanford University, (4)University of Peredeniya

Incidence rates of kidney disease of unknown etiology (CKDu) are a growing concern within global tropical agricultural areas, including the Wilgamuwa division of Sri Lanka. Agrochemical exposures in the region have been proposed as a contributing factor. Current targeted approaches provide only limited assessments of the environmental hazards to which people are exposed. Additionally, chemical degradation may lead to the introduction of potentially toxic metabolites. We conducted comprehensive organic contaminants screening of drinking water samples in CKDu endemic and non-endemic regions using non-targeted mass spectrometry and machine learning-based library matching. We exploited molecular community networks to draw connections between related compound hits within non-targeted spectra, allowing for further identification of pesticide breakdown products. Based on our screening approach with both gas and liquid chromatography, we found predictable seasonal fluxes of pesticides into drinking water wells. The agrochemicals found in this water, though not persistent, reoccur annually, allowing for acute short term and periodic long-term exposures. Specifically, the herbicide pretilachlor is detected at significantly higher rates in the endemic region of Wilgamuwa compared to two non-endemic reference regions. Beyond agrochemicals, we identified additional classes of compound exposure based on a kidney damage index leveraging the EPA CompTox database. We used kidney damage likelihood scores to highlight compounds found within the drinking water wells to inform future study including fungi-produced natural products like citrinin as synergistic or alternative candidates for kidney disease drivers.

4.08.P-We031 Systematic Screening of Nuclear Receptor Activities of Plastics

Wanzhen Chen[1], Husein Almuhtaram[1], Robert Andrews[1] and Hui Peng[1] (1)University of Toronto

Microplastics (MPs) are ubiquitous environmental contaminants that have been detected in air, soil, surface water, and drinking water. Due to increasing concerns regarding their occurrence and potential health impacts, MPs were recently included in the U.S. Environmental Protection Agency's Sixth Contaminant Candidate List (CCL 6) for drinking water. However, the biological activity and toxicological relevance of complex plastic additives remain poorly understood.

The aim of this ongoing project is to evaluate the potential biological activity of MP-associated chemicals using nuclear receptor–based in vitro assays. Extracts from pre-production pellets, consumer products, and environmentally exposed microplastics will be screened against 20 selected human nuclear receptors involved in metabolic and endocrine regulation. A modified thermal shift fluorescence assay will be used to assess

receptor–chemical interactions and identify plastic extracts with elevated toxicological potential. The results will improve our understanding of the contribution of MP-associated chemicals to the biological activity of MPs and provide mechanistic evidence to support future human health risk assessment and regulatory decision-making for MPs in drinking water.

Elucidating the Mechanisms and Kinetics of Chemical Transformation Products

4.09.T-01 Development of enviPath-PFAS: A Curated Database and Enhanced Prediction Framework for the Biotransformation of per- and Polyfluoroalkyl Substances (PFASs)

Stephanie Rich[1], Jasmin Hafner[2], Silvan Liechti[2], Flurin Jenny[2], Kathrin Fenner[2], Mojtaba Qanbarzadeh[3], Christopher Higgins[3] and Damian Helbling[4] (1)University of Zürich, (2)Swiss Federal Institute of Aquatic Science and Technology (Eawag) / University of Zurich, (3)Colorado School of Mines, (4)Cornell University

Per- and polyfluoroalkyl substances (PFASs) are persistent environmental contaminants widely used in industrial applications and commercial products. Many polyfluoroalkyl substances can be biotransformed in the environment to generate perfluoroalkyl acids (PFAAs) of regulatory concern. Understanding the complex biotransformation pathways mediated by microbial communities in the environment is critical for assessing long-term contamination risks, yet existing knowledge is fragmented across the literature and difficult to apply in remediation or risk assessment contexts.

In this work, we address the need for a centralized, standardized, and predictive framework for PFAS biotransformation. We compiled and curated published biotransformation pathway data, developed PFAS-specific prediction capabilities, and made these resources publicly accessible through the open-source enviPath platform. Using a newly developed Biotransformation Reporting Tool (BART), data from 91 peer-reviewed studies were extracted and harmonized into a machine-readable, FAIR-compliant (Findable, Accessible, Interoperable, Reusable) database. In parallel, we enhanced the hybrid expert/machine-learning prediction system within enviPath by generating new biotransformation rules tailored to PFAS chemistry and retraining models.

The resulting database contains 216 pathways, 589 compounds, and 923 reactions reported across diverse environmental scenarios. A chemical space analysis indicates broad representativeness of known PFAS classes. Automated rule generation produced 85 new PFAS-specific biotransformation rules, increasing reaction coverage to 85% within the dataset. Model evaluation using precision–recall analysis demonstrated substantial improvement in predictive performance, with the area under the curve increasing from 0.045 with the unmodified enviPath model to 0.361 in the modified enviPath model that incorporates PFAS data and the new PFAS-specific biotransformation rules.

Overall, this work establishes a scalable infrastructure for consolidating PFAS biotransformation knowledge and significantly improves predictive capability for their biotransformation pathways. These advances support more informed remediation planning and site risk assessment by enabling practitioners to anticipate PFAA formation from precursor compounds across environmental systems.

Disclaimer/Disclosure: This work was partially supported by the Environmental Security Technology Certification Program (ESTCP ER22-7962), the Strategic Environmental Research and Development Program (SERDP ER23-3697), and the U.S. National Science Foundation (Award 49100424C0005).

4.09.T-03 Elucidating the Dominant Biotransformation Pathways and Rate-Limiting Intermediates of Emerging Perfluoroalkane Sulfonamide Derivatives

Fanshu Geng[1] and Damian Helbling[1] (1)Cornell University

There is interest in assessing the occurrence and biotransformation potential of per- and polyfluoroalkyl substances (PFASs) in the environment. Perfluoroalkane sulfonamide derivatives are a class of PFASs that have received attention due to their widespread use and environmental persistence. The goal of this research was to integrate studies of PFAS biotransformation pathways and biotransformation kinetics to discover dominant biotransformation pathways, enable quantitative estimates on the formation of rate-limiting intermediates, and simulate the net formation of key biotransformation products. We selected eight perfluoroalkane sulfonamide derivatives as a class of PFASs of emerging interest and performed a series of aerobic batch experiments in bioreactors seeded with wastewater microbial communities. We identified 71 biotransformation products among the eight parent compounds, of which 42 represent unique chemical structures. We found that the spectrum of biotransformation products could be assembled into convergent biotransformation pathways that generalize our understanding of the way perfluoroalkane sulfonamide derivatives are biotransformed. Our kinetics analyses reveal that an initial monohydroxylation followed by deamination or oxidation and subsequent amide hydrolysis is the dominant biotransformation pathway. The kinetics analyses also enable estimation of the extent of formation of key rate-limiting intermediates (i.e., N-propionic acid- and N-acetic acid-substituted intermediates) and generate rate constants to simulate the net formation of perfluoroalkyl sulfonamide products. Together, our results contribute to the ongoing discovery of biotransformation products of relevant classes of PFASs and provide essential kinetics data to simulate the net formation of key biotransformation products.

4.09.T-04 Fluorinated Byproduct Formation From the Oxidation of Fluorinated Phenols

John Keenan[1], Laurinda Nyarko[1], William Pomerantz[1] and William Arnold[1] (1)University of Minnesota

In recent years, there has been an increasing number of pharmaceuticals and pesticides with fluorine incorporated into their structures. Fluorinated phenols, including fluorophenols and trifluoromethyl phenols, are often used as building blocks during fluorochemical production and can appear in the environment as transformation products of these fluorinated compounds. Due to their widespread and increasing use, fluorinated phenolic compounds can end up in drinking water and wastewater treatment systems, where they are exposed to strong oxidants during disinfection processes. By studying reactions between fluorinated phenols and various oxidants, we can get a better idea of what fluorinated byproducts are being formed in water disinfection systems. To investigate what happens to fluorinated phenolic compounds during disinfection, various fluorophenols and trifluoromethyl phenols were used as model compounds in oxidation experiments. These fluorinated phenols were exposed to hypochlorous acid and chloramine at pH 6, 8, and 10, in both uniform formation conditions and formation potential experiments. Experiments were also performed with photogenerated hydroxyl radicals. Both 19F-nuclear magnetic resonance spectroscopy and high resolution mass spectrometry were used to track the degradation of the parent compounds, identify fluorinated products, and conduct fluorine mass balances. Density functional theory computations were used to support findings. Results

show that initially, chlorine is added to several positions on the aromatic ring of the fluorinated phenols. With longer reaction times and higher chlorine concentrations, fluorinated ring-opening products, such as trifluoroacetic acid, are likely formed, with trifluoromethyl phenols being more susceptible to ring-opening than fluorophenols. Reactions with hydroxyl radicals lead to formation of fluoride and fluoroacetic acids. These results will aid in understanding the behavior of fluorinated chemicals and the formation of byproducts in water disinfection systems, in managing and regulating fluorinated contaminants, and in designing chemicals that are less environmentally persistent.

Disclaimer/Disclosure: This work was funded by the US National Science Foundation and the Minnesota Environment and Natural Resources Trust Fund.

4.09.T-05 From Human Metabolism to Aquatic Systems: Transformation and Environmental Relevance of Pharmaceuticals—a Pantoprazole Case Study

Finnian Freeling[1], Dominic Armbruster[1], Karsten Nödler[1], Uwe Kunkel[2], Marco Scheurer[3], Jan Koschorreck[4] and Thomas Ternes[5] (1)TZW: German Water Centre, Karlsruhe, (2)Bavarian Environment Agency, Augsburg, (3)Landesanstalt für Umwelt Baden-Württemberg, Karlsruhe, (4)German Environment Agency, Berlin, (5)Federal Institute of Hydrology (BfG), Koblenz

After application, pharmaceuticals and their metabolites are excreted via urine and feces. Since many compounds cannot be completely eliminated by conventional wastewater treatment plants (WWTPs), they are regularly detected in receiving waters. To date, approaches to environmental monitoring and risk assessment for regulatory purposes have focused on the parent compounds of pharmaceuticals. For instance, the environmental risk assessment of medical products for human use in the EU largely ignores transformation in the regulatory authorization procedure, allowing for a so-called “total residue approach” in which the environmental fate and toxicity of metabolites are assumed to be covered by that of the original compound. Pantoprazole (PPZ), a proton pump inhibitor, is among the top-selling pharmaceuticals worldwide. Despite its high consumption, concentrations of PPZ in urban waters are comparatively low, which can be explained by the extensive metabolism of PPZ in the human body. In this study, high resolution mass spectrometry was used to screen urine from a PPZ consumer and WWTP influent for known PPZ metabolites, identifying 4′ O demethyl PPZ sulfide (M1) as the most relevant compound for environmental analysis. Notably, M1 has not previously been reported as a human PPZ metabolite. M1 was ubiquitous in WWTP influent and effluent and in wastewater-impacted surface waters in Germany, with concentrations about 30 times higher than those of PPZ. Furthermore, quantitative structure–activity relationship (QSAR) modeling suggests that M1 may pose a higher ecological risk to freshwater organisms than the parent compound. M1 levels in suspended particulate matter from the Rhine River increased markedly over a 10-year monitoring period and were strongly correlated with annual PPZ prescription volumes in Germany. Laboratory adsorption experiments showed that activated carbon post treatment significantly enhances M1 removal, whereas ozonation rapidly degrades M1 but forms several previously unknown transformation products. These findings demonstrate that neglecting biotic and abiotic transformation reactions can substantially misrepresent the environmental occurrence and potential impact of pharmaceuticals, underscoring the need for monitoring and risk assessment approaches that consider both parent compounds and their transformation products.

4.09.T-06 Systematic Discovery of Bioactive Human Estrogen-Related Receptor γ Ligands From Phase I Biotransformation Products of ToxCast Compounds

Diwen Yang[1] and Hui Peng[1] (1)University of Toronto

Over 350,000 chemicals have been registered for commercial use in the global market, and humans are exposed to these compounds through dietary ingestion, inhalation, and dermal contact. The U.S. EPA ToxCast/Tox21 programs have conducted high-throughput bioassays to screen over 9000 commercial chemicals for toxicities; however, their transformation products generated through environmental processes and human metabolism remain largely unrecognized due to the lack of standards for conventional toxicity screening. Here, we developed a high-throughput platform to systematically screen Phase I metabolites of ToxCast compounds for protein binding activities.

To achieve this, we developed a workflow that integrates microsome-based metabolism with protein affinity selection–mass spectrometry. A total of 1,037 ToxCast compounds were subjected to Phase I biotransformation using rat liver microsomes, enabling CYP450-mediated reactions such as hydroxylation, oxidation, and hydrolysis. The resulting transformation-product mixtures were then screened against purified human estrogen-related receptor γ (ERRγ), selected for its preference for hydroxylated phenolic ligands, with epidermal fatty acid binding protein (FABP5) used as a negative control to distinguish nonspecific binding. Transformation products selectively enriched by ERRγ were prioritized as candidate bioactive metabolites for further validation.

Approximately 2,000 potential transformation-product hits were detected with LC-MS signal intensities significantly higher than those in denatured microsome controls ($FC > 5$, $P < 0.05$). Among them, five were selectively enriched by ERRγ ($FC > 10$ and $P < 0.05$), and one compound was selected for validation based on the availability of a chemical standard. This study presents a high-throughput approach for the toxicity assessment of biotransformation products without requiring authentic standards and highlights the high selectivity of ERRγ ligands recognitions.

Elucidating the Mechanisms and Kinetics of Chemical Transformation Products

4.09.P-We067 Assessing Nuclear Receptor Activities of the Ozonolysis Products of 1036 ToxCast Chemicals

Zhipeng Cheng[1], Hongru Shen[2], Jonathan Abbatt[2] and Hui Peng[2] (1)Nankai University, (2)University of Toronto

When chemical pollutants enter the environment, they undergo diverse transformation processes, generating a wide range of transformation products (TPs), some of which are benign while others exhibit greater toxicity than their precursors. Ozone is a major oxidant that drives chemical reactions through multiphase oxidation. However, ozonolysis chemistry has only been investigated for a limited number of chemicals. Moreover, information on the bioactivity of TPs remains scarce, largely due to the lack of authentic standards, which represents a major bottleneck for systematic toxicity assessment.
Protein affinity selection coupled with untargeted mass spectrometry (AS-UMS) is an unbiased platform for identifying protein-binding ligands directly from chemical mixtures. Here, we applied AS-UMS to assess the nuclear receptor activities of TPs generated by multi-phase ozonolysis of 1,036 individual ToxCast chemicals

under environmentally relevant conditions. High-resolution mass spectrometry (HR-MS) detected more than 2,000 TP features, of which approximately 200 were tentatively identified with high confidence. These identified TPs revealed a multitude of previously uncharacterized reaction pathways. In total, 49, 13, 2, and 0 TPs were identified as potential ligands for four nuclear receptors (PPARγ, PXR, ERRγ, and FXR), respectively. Four bioactive TPs were selected to validate their bioactivities through synthesized standards. By integrating high-throughput ozonolysis with AS-UMS, this study establishes a scalable framework for identifying and prioritizing bioactive transformation products, highlighting the importance of considering transformation products in chemical risk assessment.

4.09.P-We068 Characterization of Organic Micropollutant Phototransformation in Lake Okeechobee, Florida

Natalia Malina[1] and Rodrigo Restrepo[1] (1)Florida Atlantic University

Anthropogenic inputs from agricultural, industrial, and other activities substantially alter water quality. In aquatic environments, contaminants such as pesticides and pharmaceuticals are transformed through photochemical processes, potentially producing compounds that are more toxic or environmentally persistent than their precursors. Understanding contaminant transformation processes is essential for predicting the fate of pollutants in aquatic environments and assessing their potential risks to ecosystems and human health. Our research aims to characterize the phototransformation of a diverse range of organic micropollutants in Lake Okeechobee, Florida, and determine how environmental conditions influence their degradation pathways.
This early-stage study focuses on Lake Okeechobee, the largest freshwater lake in the southeastern United States and a critical source of municipal and agricultural water in South Florida. Water samples were collected from six monitoring stations across the lake and exposed to simulated sunlight spanning a broad spectral range in a custom-built photoreactor. Concentrations of selected contaminants were measured using gas chromatography–mass spectrometry (GC–MS), and degradation rates were determined over a three-day exposure period.
By comparing degradation rates and transformation pathways among sampling locations, we evaluate spatial variability in phototransformation across the lake. The results are interpreted alongside water-quality measurements collected by the South Florida Water Management District's monitoring network, including pH, temperature, turbidity, and chlorophyll a concentration. Integrating contaminant degradation data with these environmental parameters enables the identification of the primary drivers of photochemical transformation and provides insight into how these processes vary throughout the lake.
This research represents an important first step toward developing a monitoring framework to assess contaminant transformation processes in Lake Okeechobee and to support more effective water quality monitoring and management strategies beyond this ecosystem. The findings provide valuable information for regulators, water resource managers, and scientists seeking to better understand the environmental fate of organic contaminants.

Disclaimer/Disclosure: This study was funded by U.S. EPA Cooperative Agreement Grant Number MX 05D42225.

4.09.P-We069 From the Bottom Up: Biotransformation of Perfluoroalkyl Sulfonamides by

Marine Phytoplankton

Justin Sankey[1], Taylor Elpers[1], Jitka Becanova[1], Johanna Ganglbauer[1], Simon Vojta[1], Asta Habtemichael[1], Susanne Menden-Deuer[1] and Rainer Lohmann[1] (1)University of Rhode Island - Graduate School of Oceanography

Per- and polyfluoroalkyl substances (PFAS) are persistent organic pollutants ubiquitous in the environment, yet studies suggest potential biodegradation pathways for several perfluoroalkyl acid (PFAA) precursors in aqueous film forming foam (AFFF)-impacted soils. Of particular interest are perfluoroalkyl sulfonamides (FASAs), which may be scavenged by nitrogen-fixing microbes via their amine functional group, yielding terminal PFAA compounds that are more persistent and bioaccumulative. We hypothesized that similar biotransformation pathways may be active in marine phytoplankton. To assess this, we conducted batch biodegradation experiments with suspect screening and mass balance analysis to evaluate FASA transformation. Given the role of phytoplankton as a base of marine food webs, biotransformation in these organisms could represent a critical and understudied vector for PFAS trophic transfer and bioaccumulation. Transformation of FOSA (C8) to the reaction intermediate PFOSi was confirmed within the exposure study, demonstrating that marine phytoplankton are capable of PFAS biotransformation. These findings suggest that phytoplankton-driven PFAS cycling may contribute meaningfully to the distribution and persistence of terminal PFAAs in marine ecosystems.

4.09.P-We070 Kinetics of Tebuconazole Exposed to Soil and Pseudomonas putida in Microcosm Water Derived From Engineered Wetlands

Brooke Singbeil[1], Jose Luis Rodriguez Gil[2], Warren Blunt[1] and Alistair Brown[1] (1)University of Manitoba, (2)International Institute for Sustainable Development (IISD)

Tebuconazole is a fungicide that is used globally in the agricultural industry for crop preservation and seed treatment, as well as in landscape maintenance for turf and horticultural plants. Due to the widespread use, non-target organisms are at risk of exposure to its toxic effects. Thus, in vivo dissipation kinetics of tebuconazole were calculated in a previous 14-week mesocosm experiment (engineered wetland) at the Prairie Wetland Research Facility at the University of Manitoba over the summer and fall 2025. This study herein sought to determine the impacts of the addition of soil and the microbe Pseudomonas putida on the final time-point samples of the mesocosm study treatment initially spiked at 700 µg L-1. This microcosm study herein had three treatments in triplicate applied to the mesocosm water samples over 840h: 1) P. putida (biotransformation), 2) soil (sorption), and 3) P. putida and soil combined. Ultra-high performance liquid chromatography-tandem mass spectrometry and isotope dilution was used to quantify tebuconazole concentrations. Tebuconazole indicated strong initial sorption (<48h) to soil under the treatment conditions tested. When comparing the soil-only and combined microbe-and-soil treatments, they followed very similar dissipation trends; suggesting that sorption is a major fate mechanism for tebuconazole. The P. putida alone treatment did not demonstrate the ability to significantly degrade tebuconazole. However, an observed significant increase in tebuconazole concentration over 96h (means 118 to 184 µg L-1) suggested that the microbe had the potential to convert the previous study's tebuconazole transformation products (TPs) back to the parent compound. This suggests that tebuconazole TPs can exist at levels that rival the parent compound in aqueous environments, and thus current literature can underreport the total inventory of available fungicide.

4.09.P-We071 Do CYP-Mediated Metabolites Contribute to Toxicities Induced by Oxygenated PAHs in Japanese Medaka Embryos?

Yuya HOJO[1], Shusaku Fukugami[2], Masatoshi Yamasaki[1], emiko kokushi[1] and Seiichi Uno[1] (1)Kagoshima University, (2)National Institute for Environmental Studies (NIES)

Oxygenated polycyclic aromatic hydrocarbons (OPAHs) are also detected with similar or higher concentrations compared to that of PAHs especially in water columns and sediments in aquatic environment. Although their effects on aquatic organisms in the field are suspected, most of mechanisms of action are unclear. In our examinations, OPAHs induced not only effects common to PAHs in fish embryos, but also specific effects. Specific effects of OPAHs are as follows; 1,2-benzanthoraquinone (BAQ) induces the discoloration of oil droplets; and 9,10-phenanthorene quinone (PHQ) causes tail necrosis. Their symptoms led to mortality within few days during developmental growth of embryos. OPAHs activate the aryl hydrocarbon receptor (AhR) and induce CYP1A1 enzymes similar with PAHs. However, since the effects of OPAHs exhibited in fish embryos differed from those of PAHs, the underlying toxic mechanisms might be different. In the present study, we aimed to examine the toxic mechanisms of OPAHs in fish embryos using Cytochrome P450 (CYP) inhibitor. We chose Japanese medaka (Oryzias latipes) embryos as test organisms, and piperonyl butoxide (PBO) as CYP inhibitor for the examination to elucidate the toxic mechanisms. Initially, we exposed embryos to OPAHs alone and OPAHs +PBO, respectively. At the same time, we established the solvent control group using DMSO (0.1 %). As a result, the discoloration of oil droplet was observed in lower concentration of BAQ in the group added PBO than in BAQ alone group. Similarly, tail necrosis was only induced in PHQ+PBO group, whereas no tail necrosis was observed in either PHQ alone groups. We also analyzed ethoxyresorfin-O-deethylase (EROD) to evaluate CYP1A1 activity. As a result, there were not significantly different in EROD activity between OPAHs alone group and OPAHs+PBO group. These findings suggested that toxic effects of OPAHs are not primarily mediated by OPAHs metabolites depending on CYP1A1.

4.09.P-We072 A Draft Framework for Extrapolating Zebra Fish Embryo Assay Data to Human and Environmental Exposure and Risk Assessment

Trevor N. Brown[1], Alessandro Sangion[1] and Jon A. Arnot[1] (1)ARC Arnot Consulting & Research

This work presents the development of an exposure estimation framework for using zebrafish embryo (ZFE) model data in human and environmental risk assessment. The framework is built around the ZFE bioassay as a new approach methodology (NAM) and the required extrapolation of doses from the bioassays to metrics that can be directly compared with exposures that could occur in the real-world to estimate risk. Risk assessment of substances uses metrics such as margin of exposure and risk quotients which compare a substance's toxicity (hazard) to estimated exposure levels for humans or other organisms. A key aspect of these assessments is aligning hazard data with the exposure data, which means that they must be in same units in a comparable physiological space in the organism or in the exposure environment. The framework achieves this alignment with two workflows, one which extrapolates hazard data from the ZFE bioassays to humans and other receptor species, and another which uses models and measurements to determine exposure.

The major research need identified in the hazard data workflow is the development and validation of a broadly applicable ZFE TK model. This will facilitate the first key step in the hazard workflow, which is to extrapolate from the measured ZFE bioassay point of departure (POD) to an internal concentration which can be reliably

extrapolated to a meaningful concentration in humans and other receptor species. Once this key step is addressed, then there are many existing tools that can be used to align the hazard and exposure data. The remainder of the hazard workflow is reverse TK (rTK) from the internal concentration derived from the ZFE TK model to a whole body or external exposure metric, such as an administered equivalent dose (AED).

There are many experimental and modelling options available for the exposure data workflow. Which tools are suitable to use for a substance assessment depends on the information available. The exposure workflow will result in an uptake rate which is comparable to an AED calculated from the hazard workflow or an internal concentration (blood, membranes, whole-body) by applying appropriate TK models. Overall, the proposed framework provides a promising pathway for supporting scientifically robust chemical risk assessments using ZFE bioassay data to protect human health.

4.09.P-We073 Photocatalytic Decomposition of Pharmaceuticals Using BiOCl: A Study of the Impact of Alpha-Methyl Substitution on Radical Decarboxylation Degradation Pathways for Phenylacetic Acid Variants

Sree Kandhadai[1] and Elizabeth Stemmler[1] (1)Bowdoin College

Pharmaceuticals and personal care products (PPCPs) can lead to endocrine and reproductive disruption, oxidative stress, increased cancer risk, and other ecotoxicological impacts in aquatic organisms. While wastewater treatment plants can minimize the amount of organic water pollutants that enter aquatic ecosystems, they are not wholly effective, and effluent from plants can still cause ecological damage. Photocatalysis of organic pollutants by bismuth oxychloride (BiOCl) offers a cheap, environmentally friendly way to break down PPCPs in wastewater, particularly those containing carboxylic acids. However, BiOCl photocatalytic mechanisms vary widely across compound classes, and the structural motifs that influence BiOCl photocatalysis of PPCPs are not well understood. This study examines the photocatalysis of three phenylacetic acid variants: phenylacetic acid (PAA), 2-phenylpropionic acid (PPA), and 2-methyl-2-phenylpropionic acid (MPPA), each with increasing alpha-methyl substitution. Aqueous solutions of each compound were photocatalyzed by BiOCl in a UV light irradiation chamber. High performance liquid chromatography (HPLC) was used to model pseudo-first order kinetics of carboxylic acid breakdown, and both HPLC and high-resolution liquid chromatography-mass spectrometry were used to characterize degradation products. Carbonyl and alcohol degradation products, as well as hydroxylated products, have been identified for each compound. Alpha-methyl substitution did not significantly impact the degradation rate of PAA, PPA, and MPPA, suggesting that radical decarboxylation is not rate-determining for phenylacetic acid variants. However, alpha-methyl substitution is hypothesized to impact the kinetics and concentrations of the degradation products that are subsequently formed, which are currently being modeled and calculated. By advancing mechanistic knowledge of BiOCl photocatalysis, this study empowers predictions of which PPCPs are best degraded by BiOCl, as well as what degradation products may form.

Disclaimer/Disclosure: Funded by the Maine Space Grant Consortium

4.09.P-We074 Photocatalytic Degradation of Ibuprofen by BiOCl: Effect of Concentration and Light Absorption on Reaction Kinetics

Anika Nagpal[1] (1)Bowdoin College

Ibuprofen, the most commonly used NSAID, is incompletely removed during wastewater treatment processes, and has toxic effects on aquatic organisms when released into the environment. Photocatalysis, as a cheap and environmentally safe process, poses a promising method to degrade pharmaceuticals and other pollutants in wastewater. There are many existing and contradictory models for the kinetics of photocatalytic reactions, and a clear understanding of the reaction kinetics and absorbance effects are important for designing optimal conditions for photocatalytic technology and improving experimental design to compare mechanisms of photocatalytic degradation for different contaminants. The study looks at the kinetics of photocatalysis of ibuprofen with BiOCl with varied ibuprofen concentrations. This study also applies a kinetic model to account for absorbance effects of ibuprofen and its degradation products by incorporating Beer's law into integrated rate equations with the goal of determining intrinsic rate constants. Preliminary results suggest that light attenuation explains a decrease in reaction rate and rate constant as initial ibuprofen concentration increases. This work advances efforts to more accurately model kinetics that would impact photocatalysis in actual wastewater.

4.09.P-We075 The Impact of Structural Variations on the Kinetics and Products of Photocatalytic Degradation of Phthalates by BiOCl and TiO2

Oliver Tannahill[1], Fiona Gallagher[1] and Elizabeth Stemmler[1] (1)Bowdoin College

Pharmaceutical and personal care products (PPCPs) are found as environmental pollutants that enter natural waterways through industrial production and domestic use. Phthalates are a class of compounds found in natural waters that can bioaccumulate and cause adverse effects in aquatic ecosystems. Current wastewater treatment systems fail to eliminate these pollutants, necessitating innovative technologies to reduce the release of phthalates into the environment. Photocatalysis is an emerging method for pollution remediation, where polluted water is exposed to UV light in the presence of a catalyst. An excited catalyst will ideally react with water, oxygen, or directly with a target compound to break the pollutant into harmless byproducts. Different photocatalysts degrade through varying mechanisms. By determining these mechanisms, the situational uses of certain photocatalysts can be better understood. TiO2 is a photocatalyst known to generate reactive oxygen species, while the reaction pathway of BiOCl is not as well understood. In this investigation, phthalate variants, monobutyl phthalate, and phthalic acid, were degraded with UV light and TiO2 or BiOCl catalyst. Samples were taken at fixed intervals and analyzed via high-performance liquid chromatography to determine degradation kinetics. This was used in tandem with liquid chromatography-mass spectrometry to analyze the photoproducts, providing insight into photoproduct structure and potential degradation mechanisms. When degrading phthalates, BiOCl produced fewer photoproducts than TiO2. Photoproduct analysis suggested that TiO2 degraded phthalates using a hydroxyl radical generation mechanism, whereas the reaction with BiOCl occurred through a different reaction pathway. The presence of carboxylic acids on phthalates led to higher degradation rates by BiOCl. When photoproducts contained carboxylic acids, BiOCl led to more complete degradation of target pollutants.

4.09.P-We076 In Vivo Biotransformation and Toxicokinetics of 6PPD-Quinone in

Chinook Salmon (Oncorhynchus tshawytscha)

Wei Wang[1], Prarthana Shankar[2], Ellie Dalsky[2], Paxton Bachand[2], John D. Hansen[2] and Edward Kolodziej[3] (1)Interdisciplinary Arts and Sciences, University of Washington Tacoma, Tacoma, WA 98402 ; Center for Urban Waters, Tacoma, WA 98421, USA, (2)U.S. Geological Survey, Western Fisheries Research Center, 6505 NE 65th Street, Seattle, WA 98115, USA, (3)University of Washington Tacoma

The widespread release of tire wear particles and associated chemical leachates into aquatic ecosystems has raised significant ecological concerns. Among these contaminants, the tire rubber antioxidant transformation product N (1,3 dimethylbutyl) N'-phenyl p phenylenediamine quinone (6PPDQ) is acutely toxic to several culturally and economically important salmonids. Although acute lethality is well documented, major knowledge gaps remain regarding in vivo toxicokinetics and biotransformation pathways that may underlie species specific differences in 6PPDQ sensitivity. Understanding these pathways is essential for elucidating mechanisms of toxicity and detoxification in fish. This study presents a xenometabolomic analysis of Chinook salmon (Oncorhynchus tshawytscha) exposed for 96 hours to 10 µg/L 6PPDQ under static conditions. High resolution mass spectrometry with suspect and non targeted screening was used to identify biotransformation products and characterize metabolic kinetics across five timepoints. Water chemistry data showed significant declines in 6PPDQ concentration in tanks with fish compared to tanks without fish ($p < 0.0001$), confirming active chemical uptake. Tissue analyses revealed systemic distribution, with 6PPDQ detected in liver, gill, and brain within four hours. This study provides the first evidence of in vivo 6PPDQ biotransformation in fish brain, demonstrating neurological penetration and localized metabolism. We identified 25 biotransformation products, including six major metabolites detected across the three organs. Structural characterization supported by MS/MS fragmentation revealed a diverse metabolic network involving Phase I transformations and Phase II conjugation pathways. Temporal analysis showed distinct isomer specific behaviors among mono and di hydroxylated metabolites, including variation in time to maximum concentration. These findings provide new insight into systemic distribution and detoxification pathways of 6PPDQ in a relatively tolerant species. Ongoing work includes parallel xenometabolomic analyses in 6PPDQ sensitive coho salmon (O. kisutch) at lethal exposure concentrations and RNA analyses of organs from both species. This work supports more accurate risk assessment of 6PPDQ and other emerging rubber derived contaminants.

4.09.P-We078 Mechanistic and In Silico Insights Into Nitrosamine Mitigation in Cosmetics and Personal Care Products To Mitigate Risks to Human and Environmental Health

Jillian Brejnik[1] and Jakub Kostal[1] (1)George Washington University

Most nitrosamines are classified as carcinogens that are formed in a reaction between a vulnerable amine and a nitrite compound. Their carcinogenicity arises primarily from Cytochrome P450 metabolic activation, forming highly electrophilic diazonium ions capable of alkylating DNA. Although originally found in pharmaceuticals, nitrosamines can also form in cosmetic and personal care products, thus impacting a large group of consumers. Raw materials, preservatives, reaction conditions, and production workflows can all be related to the presence/formation of nitrosating agents, such as the nitronium ion, nitrogen trioxide, or NOx in a cosmetic formulation. To prevent nitrosamine formation, the addition of a scavenger such as an antioxidant or flavonoids can be added to the formulation. The purpose of the scavenger molecule is to compete with the amine for the nitrosating agent to produce an inactive conjugate, thus allowing the amine to remain intact with no impurity. In silico modeling using Density Functional Theory (DFT) can provide a cost-effective way to accurately screen

potential transformations and compute the kinetics and thermodynamics of nitrosamine formation potential. Calculated energetics can, in turn, be leveraged to best understand the underlying structural drivers of nitrosamine formation and subsequently identify the most benign formulation component alternatives and/or to design the most suitable scavenger(s) for a particular formulation. Our approach considers a range of secondary amines, nitrosating agents and commonly used solvents, which have not been previously studied, to develop a comprehensive framework for risk mitigation in formulation design. Since not all nitrosamines are equally potent mutagens/carcinogens, the toxicity potential of the impurity is concurrently assessed using the regulator-approved Carcinogenic Potency Categorization Approach (CPCA). This combined in-silico approach aims to enhance the evaluation of both existing and future formulations, enabling concerns to be addressed at early stages of the design process to limit the adverse effects of cosmetics and personal care products on human and environmental health.

Emerging Contaminants in Our Changing World: Impacts of Climate Change, Wildfires and Policy

4.10.T-01 Can Perfluoroalkyl Carboxylic Acids (PFCAs) Be Remobilized to the Atmosphere Through Dust and Biomass Burning?

Cora Young[1] (1)York University

Perfluoroalkyl carboxylic acids (PFCAs) are found in the atmosphere, where they can contribute to contamination of remote regions. Atmospheric PFCAs can be emitted directly and formed from the oxidation of volatile precursors. These PFCAs are deposited to the Earth surface through wet and dry deposition on a relatively short timescale. In the past few years, remobilization of PFCAs via sea spray aerosol has been proposed to contribute to the atmospheric burden and transport of PFCAs. However, remobilization may also be possible from dust storms and biomass burning, both of which are expected to increase in a changing climate. The prevalence of these processes can be assessed through the presence of atmospheric markers, Ca2+/Mg2+ for dust and K+ for biomass burning. Using relationships between these markers and PFCAs in atmospheric deposition samples and in situ atmospheric measurements, the likelihood of dust and biomass burning remobilization will be discussed.

4.10.T-02 Elemental Tracers of Residential PFAS Contamination Following the 2025 Los Angeles Wildfires

Yumin Zhu[1], Aryenne Ysabelle Rodrigo[1], Parham Azimi[2], Evan Routhier[1], Connor Olson[1], Zhiji Hu[3], Ethan Sontarp[1], Euna Kim[1], Zahra Keshavarz[2], Hannah Healy[4], Christopher Olivares[5], Joe Allen[2], Colin Thackray[1] and Elsie Sunderland[1] (1)Harvard University, (2)Harvard T.H. Chan School of Public Health, (3)Harvard John A. Paulson School of Engineering and Applied Sciences, Harvard University (SEAS), (4)Harvard T.H. Chan School of Pubic Health, (5)University of California Irvine (UC Irvine)

Per- and polyfluoroalkyl substances (PFAS) are widespread in built and natural environments but effects of wildland-urban interface (WUI) fires on their distribution and detection are poorly understood. We analyzed 57 targeted PFAS in residential soil and indoor ash samples collected from burned and unburned houses following the January 2025 Los Angeles, USA wildfires. We detected 46 PFAS in ash and 40 in residential soils. Back-

trajectory modeling showed a plume of fire-derived particle deposition across the sampling region. Summed concentrations in ash varied by three orders of magnitude across households (22-19,000 ng/g). Indoor ash from burned households was enriched in summed PFAS by 27× relative to soil from the same households. For both unburned and burned soil and ash samples, the greatest component of summed PFAS mass (67-80%) consisted of the shortest carbon chain length compound, trifluoroacetic acid (TFA). TFA concentrations were highest in burned ash (geometric mean burned ash = 1200 ng/g) but did not differ significantly between burned and unburned residences. However, ash and soil samples displayed disparate associations with elemental fire markers and organic carbon. In burned ash and soil, TFA was positively associated with organic matter content (Spearman rho=0.62 to 0.71) and inversely correlated with recalcitrant tracers of the combustion of electronics and structural materials such as rubidium, barium and aluminum (rho=-0.65 to -0.79). Highly variable TFA concentrations likely reflect a balance between mineralization in the highest temperature wildfires and production via thermolysis of fluoropolymers in low temperature/smoldering burns that produce organic rich ash residues.

Disclaimer/Disclosure: Financial support for this work was provided by a gift from the Spiegel Family Fund to the Harvard T.H. Chan School of Public Health and the National Institute of Environmental Health Sciences (NIEHS) Superfund Research Program (Award Number P42ES027706).

4.10.T-03 Discovery, Characterization, and Risk Assessment of Vapor-Phase Chemical Exposure From Wildfire Smoke

Kelly O'Malley[1], Lisa Bramer[2], Diana Rohlman[1], Katrina Waters[3] and Kim Anderson[1] (1)Oregon State University, (2)Pacific Northwest National Laboratory, (3)Pacific Northwest National Laboratory (PNNL)

The incidence of large wildfires over 1,000 acres and their occurrence in wildland-urban interface (WUI) areas have continued to increase globally, making wildfires an emerging air quality concern. Methods to quickly identify and quantify concentrations of vapor-phase (bioavailable) organic contaminants in complex wildfire smoke mixtures are needed to assess human health risk from exposure. The objectives of this study are to discover and quantify novel bioavailable chemicals linked to wildfire smoke, to characterize their potential sources and risk, and to explore chemical composition in relation to WUI wildfires. Low-density polyethylene (LDPE) passive samplers were deployed by trained community members in air cages before and during wildfires at twelve locations in the Western United States. All samples were quantitatively analyzed for PAHs, oxygenated PAHs (OPAHs), flame retardants, fragrances, phthalates, and pesticides using gas chromatography (GC), tandem GC-mass spectrometry (GC-MS/MS) or GC-MS. A 1530 chemical semi-quantitative GC-MS screening method was also performed. WUI acreage burned was assessed with publicly available WUI and fire perimeter data. 102 bioavailable chemicals were potentially linked to wildfire smoke, including 50 PAHs, 6 OPAHs, 8 pesticides, 9 fragrances, 4 flame retardants, 9 phthalates, and 16 from the 1530 screen. Over 20 of these chemicals have not been previously linked to wildfire smoke to the best of our knowledge. Concentrations or detection frequencies for 18 of these chemicals, primarily PAHs and OPAHs, were statistically higher during wildfires, highlighting that these chemicals may be more likely to be present in all wildfire smoke. Risk from inhalation exposure was estimated to significantly increase during wildfires. 33 chemicals were identified to potentially originate from urban and industrial areas that could have been burned and released into smoke plumes during WUI wildfires. Concentrations of 7 urban chemicals increased at sites impacted from smoke by fires that burned more WUI acreage, suggesting exposure to different chemical mixtures in these areas. These

chemicals include bis(2-propylheptyl) phthalate, diethyl phthalate, zinc diethyldithiocarbamate, 1,2,4-trichlorobenzene, 4-methoxyphenol, drometrizole, and biphenyl. Identifying bioavailable components of wildfire smoke can improve our understanding of human exposure to wildfire smoke and how that may change depending on where the fire spreads.

4.10.T-04 Ash To Tap: Chemical Profiling and Risk Assessment of Wildland-Urban Interface Fire Residues

Cresten Mansfeldt[1] and Fernando Rosario-Ortiz[1] (1)University of Colorado Boulder

Wildfires at the wildland-urban interface (WUI) pose emerging chemical risks in both novel chemical hazards and impacted exposure routes. The WUI represents developed regions in which urban structures either border or intermingle with forests, grasslands, or other wildland, comprising ~35% of residential structures in the United States. When compared to wildland fires, the composition of the synthetic components found within the urban footprint alters fire chemistry. Further, WUI fires potentially damage water treatment and distribution infrastructure, introducing new exposure pathways that require management beyond drinking water source protection. In combination, the WUI requires a remapping of wildfire risk frameworks. Therefore, this study focuses on first assessing the novel chemical profile and toxicity of WUI wildfire ash and impacted waters. Representative materials comprising residential structures as well as wildland-collected material were combusted in controlled laboratory conditions, and the chemical profile of the resulting ash material was extracted in a synthetic rainwater. A suite of analytical tools, including high-resolution and inductively coupled plasma mass spectrometry, were employed to characterize the resulting leached organic and inorganic components. Notably, chlorinated organics and calcium, copper, and other trace metals often distinguished the WUI from wildland ash. Translating this chemical mixture into a hazard, this study additionally employed a suite of bioanalytical tools to assess various toxicity endpoints. Concerningly, those combusted materials that contained PVC construction material consistently displayed higher toxicity. After assessing the toxicity of the charred debris, the hazard is transformed to risk by mapping contamination potential along a water treatment and distribution system. Source water management is able to remediate the majority of these chemical constituents, albeit at a higher operational cost. However, impacted WUI water distribution infrastructure heightens risks of both contaminant intrusion into the pipe network and novel contaminant formation through the interaction of ash materials with residual water disinfectants. Overall, the WUI requires a continuous and expanding assessment of the mechanisms of chemical formation, the toxicity of the resulting products, and the transport routes potentially exposing residents to manage the pervasive and expanding wildfire risk.

4.10.T-05 Wildfire Impacts on Drinking Water Assessed Using Nontarget Screening

Thomas Young[1], Luann Wong[1] and Christopher Alaimo[1] (1)University of California Davis (UC Davis)

The changing climate has caused a rapid increase in the incidence of wildfires worldwide. Beyond the immediate danger to human health, longer-term threats can persist after the fire has been extinguished. One such threat is the contamination of the local water system through both the infiltration of ash and debris and the thermally-induced changes to piping and storage reservoirs. Both cause the introduction of volatile and semi-volatile compounds (VOCs and sVOCs) including polycyclic aromatic hydrocarbons (PAHs), carbonyls, benzene derivatives, and halogenated organics. Advancements in both analytical hardware and software make it

possible to further explore data acquired for the analysis of known targets for the presence of unknown compounds formed during the combustion of both natural and anthropogenic materials during a wildfire event. The purpose of this study is to apply the techniques for non-targeted analysis to water samples taken from a public water system impacted by the August 2023 fires in Maui, Hawaii, USA. Eighteen 1L samples were collected from varying points in the system, extracted using solid-phase HLB cartridges, and then concentrated and analyzed via gas chromatography and quadrupole time-of-flight mass spectrometry. The resultant data was processed using both Unknowns Analysis (Agilent Technologies) and MS-DIAL (Riken?) to tentatively identify unknown features in each sample and then to align those features across the sample set. Toxicity models such as the VEGA suite of QSAR models as well as databases including the EPA Comptox Chemicals Dashboard can then be used to prioritize the positive identification of non-target compounds-of-concern using analytical standards. This workflow returned NIST library annotations for 435 unknown features which after further curation based on chromatographic and spectral quality produced a list of 86 level 1 (confirmed identification) or level 2 (probable structure or isomer based on required metrics) features. These include targets such as PAHs and halogenated disinfection byproducts as well as numerous nontarget compounds, the health effects of which are potentially on-par with those typically monitored and regulated post-wildfire. This nontarget approach, when combined with the traditional targeted analysis, paints a more complete picture of the wildfire-induced organic contamination of a public water supply and its potential threat to human health.

4.10.T-06 Distribution, Accumulation, and Remobilization of Organic Pollutants by Flood Events on the Rur River, Germany

Christina van der Marel[1], Karolina Nowak[2] and Jan Schwarzbauer[3] (1)Environmental Geochemistry, Institute for Integrated Natural Sciences, University of Koblenz; Institute for Organic Biogeochemistry in Geo-Systems, RWTH Aachen University, (2)Environmental Geochemistry, Institute for Integrated Natural Sciences, University of Koblenz, (3)Institute for Organic Biogeochemistry in Geo-Systems, RWTH Aachen University

Extreme weather events and natural disasters such as heavy precipitation and flooding can cause severe destruction and impacts on river systems and the adjacent environment (including natural habitats as well as anthropogenically modified areas). As a result, an unusual input, but also the remobilization of various organic pollutants into or within river systems occurs.
The focus of this investigation was on the indirect effects of floods and the corresponding dispersion of persistent organic pollutants (POPs) in different compartments along the course of the Rur river in western Germany. Event-related sampling of various floodplains was performed after two floods in 2021. Furthermore, regular, bi-annual sampling campaigns of the riverbed sediments were carried out to assess the organic pollution in terms of concentrations, distribution, accumulation, and (re)mobilization along the river course.
Non-target screenings using Gas Chromatography/Mass Spectrometry (GC/MS) revealed the presence of different POP groups, including PAHs (polycyclic aromatic hydrocarbons), PCBs (polychlorinated biphenyls), LABs (linear alkylbenzenes) and various industrial compounds (e.g., di-iso-propylnaphthalenes). These POPs are indicators for petrogenic and urban (wastewater) pollution as well as for emissions from historical and current industrial or mining activities.
For both the riverbed and the floodplains, concentrations detected after the extreme summer flood were higher than in winter (up to mg/gTOC). Substantially higher river discharges in summer led to more severe flooding and associated damage across the entire catchment area. Particularly, the main tributaries had a major impact on pollutant introduction and distribution. Furthermore, structural features such as dams and reservoirs or

(re)naturalized areas showed a high relevance in flood-related pollutant dispersion.
Interestingly, the riverbed was found to be more polluted than the floodplain sediments. This finding suggests that instead of a washout effect to adjacent river areas, the floods directly affected the accumulation and enrichment of pollutants in the riverbed itself.
Overall, the identified distribution patterns of various POPs provide an important basis for a comprehensive risk assessment regarding the short- and long-term effects of flood events.

Disclaimer/Disclosure: C.M. was financially supported by the RWTH Aachen University Scholarships for Doctoral Students.

Emerging Contaminants in Our Changing World: Impacts of Climate Change, Wildfires and Policy

4.10.P-Tu001 Improving Fertilizer Environment and Climate Impacts in Agricultural Soils Using Dynamic Chambers: Observations From Two Canadian Campaigns

Trevor VandenBoer[1] (1)York University

There is significant pressure on the Earth system through humanity's agricultural activities. A substantial portion of that pressure is from the perturbation of elemental cycles, such as that for nitrogen (N). Disruption of the N cycle has numerous negative effects, e.g., interference with ecosystem function through eutrophication, impacts on air quality, and production of the potent greenhouse gas (GHG) nitrous oxide (N2O). Global fixation of ammonia (NH3) and release of reactive nitrogen (Nr) through fertilizer use, as well as combustion of fuels, have led to never-before-seen Nr levels, as humans fix N at double the rate of natural systems. Fixation and transport of N-related products is central to the success of Canadian agriculture but also contributes to its environmental climate burden. Residual soil N has been increasing in Canadian soils, and globally N-use efficiency (NUE) has been decreasing for decades. This is often attributed to inefficiently utilized Nr resources, where, instead of contributing to crop yields, N is leached, denitrified, or accumulated in root zones of agricultural soil. Improving agricultural N-use by growers in Canada remains a challenge with major knowledge gaps, which we have begun to address with comprehensive field scale measurements with newly developed dynamic flux chambers for reactive gases, so that the agronomy sector may improve its NUE alongside reducing its environmental impacts. These were deployed during two field campaigns to simultaneously measure fluxes of: NO, NO2, HONO, NH3, N2O, CH4, H2O, and CO2. In the first two-week campaign, testing of the new chambers was made alongside standard eddy covariance flux techniques to validate chamber performance for Nr gases, while also facilitating proof-of-concept capabilities for conducting in situ experimental perturbations. The second campaign was conducted over 6 weeks from bare tilled soil through to planting and germination of commercial crops, under standard use by industrial collaborators. Soil characteristics, microbial communities, Nr stable isotopic composition, and lab-based experiments on field soil samples were all investigated to provide insight into reservoirs and controls on nitrogen use spanning biological through chemical pathways.

4.10.P-Tu002 Investigating the Evaporation and Dissolution Loss of New Generation Low

Sulfur Fuel Oils in Oil Spill Scenarios Using Multidimensional Gas Chromatography

Jared Faulkner[1], Han Bao[1], Shira Joudan[1] and James Harynuk[1] (1)University of Alberta

The International Maritime Organization 2020 mandate has introduced a new generation of low sulfur fuel oils (LSFOs), mandated to have a sulfur content of <0.5 wt% to reduce emissions of sulfur and nitrogen oxides. While LSFOs can reduce atmospheric emissions, their impact on marine ecosystems in spill scenarios remains poorly understood due to their recent manufacture. This problem is further compounded with the recent introduction of Arctic trade routes, which are now accessible due to receding glaciers and climate change. Understanding risks to these unique marine ecosystems is the primary motivation for this work. Comprehensive two-dimensional gas chromatography (GC×GC) paired with time-of-flight mass spectrometry (TOFMS) and flame ionization detection (FID) were used to characterize and assess weathering processes, particularly the evaporation and dissolution loss of LSFOs in marine environments. To understand which components evaporate or move into the aqueous phase, 4 LSFOs (B20 biodiesel, ultra low sulfur diesel, very low sulfur fuel oil, and low sulfur fuel oil) were assessed under laboratory conditions. Evaporation experiments were conducted by bubbling nitrogen gas through samples of oils at a constant flow rate. Aliquots of each oil were collected at fixed time intervals for analysis by GC×GC-FID. To study the dissolution of LSFOs, water accommodated fractions (WAFs) of each fuel were prepared and subsequently analyzed to characterize petroleum compounds entering the aqueous phase. Over the course of 9 days, all oils exhibited evaporative loss. Specifically, compounds with less than 12 carbon atoms experienced evaporative loss, and compounds with less than 8 carbons were fully evaporated across all oils after 5 days. Compound characterization in WAF samples is ongoing, but will include the development of effective extraction techniques and subsequent identification and quantification of compounds of interest. Preliminary results suggest that compounds partitioning into the aqueous phase comprised mostly of small aromatic hydrocarbons (e.g.: naphthalene), cyclic aliphatic compounds (e.g.: decalin), and heteroatomic compounds (e.g.: cresol). This study aims to provide an initial understanding of weathering processes affecting LSFOs under laboratory conditions. This will provide a starting point to inform oil spill monitoring and risk assessment and guide future studies of the risks associated with these new fuels in arctic marine ecosystems.

4.10.P-Tu003 Thermal Oxidation Promotes the Release of Dissolved Carbon From PVC and PET Microplastics

Andrea Arredondo Navarro[1], Karen McGuire-Diemer[1], Sabrina Farias[1], Angelica Benavidez[2], Jose Cerrato[2] and Jorge Gonzalez-Estrella[1] (1)Oklahoma State University, (2)University of New Mexico

We evaluate the release of dissolved carbon (DC) from polyvinyl chloride (PVC) and (PET) microplastics (MPs). It is known that thermal oxidation alters the chemical structure and reactivity of polymers, however, the specific mechanisms influencing the release of DC leaching from MP remain poorly understood. Our results showed that thermal oxidation decreased chlorine concentration by 96% in PVC, increased carbonyl index from 0.397 to 0.504 in PET, and the oxidation index from 0.151 to 0.506 in PVC. No significant DC leaching occurred in PET; however, leaching increased 15-fold in PVC 250 ºC compared to non-oxidized PVC. Kinetic data for DC leaching was best fit to the biphasic model for all oxidation conditions of PVC. However, goodness of fit decreased as a function of thermal oxidation, with adjusted R2 values decreasing from 0.95 in non-oxidized PVC to 0.85 to 0.82 in PVC exposed to 100 ºC and 250 ºC, respectively. Our results indicate that thermal oxidation distinct changes the surface and bulk chemistry of MPs which consequently modifies their

reactivity in aqueous media

Disclaimer/Disclosure: This research was supported by NSF CAREER Award (2338225) and by the National Institute on Minority Health and Health Disparities (Award Number P50MD015706). The content is solely the responsibility of the authors and does not necessarily represent the official views of these institutions.

4.10.P-Tu004 Large Declines in Subarctic Marine Mammal Organofluorine Concentrations Reveal Impacts of PFAS Production Shifts and Drivers of Ecosystem Response

Jennifer Sun[1], Euna Kim[2], Colin Thackray[2], Heidi Pickard[2] and Elsie Sunderland[2] (1)San Francisco Estuary Institute, (2)Harvard University

The ocean is thought to be the terminal sink for per- and polyfluoroalkyl substances (PFAS), yet the timescales over which marine ecosystems respond to changes in PFAS production and use remain poorly understood. Industry and stewardship programs phased out the most abundantly produced legacy PFAS in the early 2000s due to toxicity concerns, but they have since been replaced by shorter carbon chain and “novel chemistries”. Past work hypothesized likely increases in these replacement chemistries that were not previously quantifiable. To address these gaps, we measured bulk extractable organofluorine (EOF) and a broad suite of targeted and suspect PFAS in archived liver and muscle tissues from pelagic Subarctic pilot whales. Results show EOF concentrations peaked in 2011 and declined by over 60% by 2023. Among a broad suite of targeted and suspect PFAS measured using high-resolution mass spectrometry, only one was consistently increasing through 2023. Tissue concentrations of four main legacy PFAS that accounted for over 75% of EOF were all decreasing by 2023. The timing of peak concentrations depended primarily on whether they were transported to the subarctic by ocean circulation or atmospheric deposition, with the latter declining much faster.

We further evaluated the mechanisms driving the temporal patterns of legacy PFAS accumulation using oceanic transport and bioaccumulation models that were forced by a spatially and temporally-distributed global emission inventory. Results indicate variable timescales of response across ocean basins, but suggest that the decadal-scale lags between production and food web bioaccumulation observed in the North Atlantic are primarily driven by marine transport processes. Large declines in tissue concentrations in this study reinforce the effectiveness of phase-outs in chemical production. However, other work showing stable or increasing EOF in human serum suggests many emerging PFAS with more neutral physicochemical properties may be preferentially accumulating in terrestrial and nearshore environments compared to legacy PFAS.

4.10.P-Tu005 Exploring the Environmental Fate of Ultrashort Chain per- and Polyfluoroalkyl Substances and Haloacetic Acids

Azka Attar[1] and Shira Joudan[1] (1)University of Alberta

Ultrashort chain per- and polyfluoroalkyl substances (uscPFAS) are a class of ubiquitous fluorinated contaminants with a chain length of less than 4 carbons. In the environment, they are often oxidative transformation products of heat transfer fluids, fire suppressants, and other consumer products. Similarly, halogenated acetic acids (HAAs) can form through the atmospheric oxidation of halogenated solvents and refrigerants. The formation of uscPFAS and HAAs through the atmospheric oxidation of volatile precursors

enhances their potential for long-range transport, resulting in their detection in remote environmental matrices such as ice cores, Arctic aerosols, and surface waters. Despite their widespread detection, the contribution of localized industrial sources, like coal mining, to the atmospheric deposition of uscPFAS and HAAs remains less studied. This study focuses on optimizing an analytical method using supercritical fluid chromatography for the quantitative determination 14 uscPFAS and HAAs for trace analysis in atmospheric deposition samples. Instrumental analysis will be performed using a Waters ACQUITY UPC² system coupled to a Xevo triple quadrupole mass spectrometer and a Torus Diol column. Instrument tuning parameters, including capillary voltage, cone gas flow, collision energies, desolvation gas flow and temperature, as well as makeup solvent composition and flow rate, are optimized to maximize signal-to-noise ratios and minimize limits of quantitation. To reach the quantitative limits required for instrumental analysis, solid phase extraction using weak anion exchange cartridges is employed for sample preconcentration. The optimized workflow will be applied to snow and ice core samples from Canada to elucidate temporal and spatial trends and to improve our understanding of the atmospheric deposition of uscPFAS and HAAs.

4.10.P-Tu006 Atmospheric Perfluoroalkyl Carboxylic Acid Formation Potential (APFP): A New Tool for Assessing Policy Trade-Offs

Cora Young[1], Shira Joudan[2] and Trevor VandenBoer[1] (1)York University, (2)University of Alberta

Atmospheric formation is a major source of perfluoroalkyl carboxylic acids (PFCA) to the environment. The number of potential fluorinated precursors is inversely related to chain length, with the shortest PFCA, trifluoroacetic acid, having numerous potential precursors. Atmospheric formation can explain observed levels of PFCAs in diverse locations, including urban air Arctic ice caps. There are numerous precursors that can form PFCAs through atmospheric oxidation, including fluorotelomer compounds and chlorofluorocarbon replacements. Formation of PFCAs is typically reported as a molar yield of the precursor product for a given chemical loss process. This chemical yield is not readily digestible by non-chemists. We propose a new metric, the atmospheric PFCA formation potential (APFP) that can be used by policymakers. This mass-based definition is more consistent with other metrics used by policy makers, including the global warming potential. This new metric allows for better assessment of the overall impacts of PFCA precursor chemicals. For example, this allows emissions of precursor chemicals, typically reported in mass units, to be directly related to the mass of PFCAs that will be formed from their ultimate atmospheric degradation. In addition, the trade-offs between climate and PFCA formation can be readily assessed. Examples of how the APFP can help in our evaluation of precursor usage will be presented.

4.10.P-Tu007 Temperature and Relative Humidity As Drivers of Volatile Organic Compound and Aldehyde Emissions From Flooring Materials and Their Installation Systems

Patrick Chepaitis[1], Fatima Ahmad[1] and Taryn Waddey[1] (1)UL Research Institutes

Flooring installations involve multiple building materials, flooring, underlayments, and adhesives, all of which can emit volatile organic compounds (VOCs) and aldehydes into indoor air. Emissions testing rarely evaluates these materials as a complete system and is typically performed under fixed laboratory conditions that do not reflect fluctuations in temperature and relative humidity (RH), which are common in occupied buildings and in

vacant spaces not conditioned by HVAC systems. As a result, current emissions data may underestimate potential indoor exposures.

This study evaluates VOC and aldehyde emissions from various flooring materials and adhesive products under environmentally relevant indoor conditions. Testing was performed in controlled microchambers at three temperatures (23 °C, 27 °C, and 35 °C) and three humidity levels (35%, 50%, and 65%) to reflect regional variation and the potential for extreme weather events that could influence the indoor environment. VOCs were analyzed using Tenax sorbent tubes with thermal desorption gas chromatography-mass spectrometry (TD-GC-MS), and aldehydes were analyzed using 2,4-dinitrophenylhydrazine (DNPH) cartridges with high-performance liquid chromatography (HPLC).

Emissions varied by material type and environmental condition, indicating that indoor exposure can change substantially with temperature and RH. Engineered hardwood samples consistently emitted acetaldehyde as the dominant aldehyde (≈33–65 µg/m3), while formaldehyde remained below detection or at low concentrations. Adhesives showed more complex aldehyde profiles, including butanal, hexanal, benzaldehyde, propanal, and acetone, with several compounds exceeding 100 µg/m3 across multiple testing conditions. A plant-based adhesive (PBA) emitted acetaldehyde under all conditions, while formaldehyde appeared only at the highest temperature. VOC emissions also differed by material: ceramic tile emitted few compounds, whereas the PBA emitted the most, with more than 50 confirmed VOCs. Temperature was the primary driver of emissions, while RH had little overall effect but increased the PBA's VOC emissions at lower temperatures.

These findings demonstrate that installation materials are the primary aldehyde sources in flooring systems and that environmental conditions influence emissions in material-specific ways. Accounting for this variability in standard testing protocols could improve indoor exposure models and strengthen risk characterization.

Emerging Contaminants in Water of Developing Countries for Sustainable Management

4.11.P-We161 Cumulative Ecological Risk of Pesticide Mixtures in an Agricultural River of the Pampa Region: Identifying Critical Contaminants for Practice and Policy Reform

Julie C. Brodeur[1], Ana Clara Caprile[2], M. Romina Schiaffino[3], Ariana Rossen[4], Diego Cristos[2], Natalia B. Godoy[2] and Mara I. Sagua[3] (1)Conicet, (2)INTA, (3)Universidad Nacional del Noroeste de la Provincia de Buenos Aires, (4)Instituto Nacional del Agua

Agricultural breadbaskets are vital for global food security, yet reliance on pesticides poses a threat to regional aquatic ecosystems. This study evaluates the cumulative ecological risk of pesticide mixtures in a river system of Argentina's Pampa region, a global agricultural heartland. Over one year, 66 pesticide residues were monitored monthly at four sites. All samples contained complex mixtures of 11 to 30 pesticides. The detected pesticides are commonly used in the region, and their spatiotemporal variability aligns with local agricultural practices. Despite their widespread use, many of the pesticides identified are reported for the first time in Pampean waters, which reflects the lack of environmental surveillance in this highly productive region. Three risk assessment approaches were compared to evaluate potential impacts to aquatic ecosystems: A Risk Quotient (RQ) based on predicted no-effect concentrations (PNEC), a Risk Quotient based on the Sum of Toxic

Units (RQSTU), and the multi-substance Potentially Affected Fraction (msPAF). All three risk assessment methods indicate that pesticide mixtures pose significant year-round toxic pressure to the aquatic community, with arthropods being the most vulnerable though risk to primary producers and fish was also evident. The RQ method identified 21 potential risk agents. A more refined analysis using msPAF pinpointed six key pesticides (flumioxazin, flurochloridone, chlorpyrifos, b-cyfluthrin, bifenthrin, fenvalerate) as the primary drivers of the mixture risk. However, the RQSTU approach identified only four of these six pesticides, indicating a potential underestimation. Our results demonstrate that a tiered approach, using RQ for initial screening followed by msPAF for definitive assessment, is the most effective and efficient strategy, with the intermediate RQSTU analysis of limited value. Despite widespread contamination, mitigation is feasible and targeting the identified set of six pesticides for regulatory review could reduce ecological risk. This study provides a validated, actionable strategy for evidence-based environmental management in intensive agricultural systems worldwide, highlighting the feasibility of targeted interventions for sustainable agricultural practice

4.11.P-We162 Occurrence of Environmental Contaminants in Brazilian Surface Waters: From Analytical Method Optimization to Environmental Detection

Mariana Oliveira[1], Ananda Lima Sanson[2], Amanda de Vasconcelos Quaresma[3], Emília Marques Brovini[4], Gabriel Reis Alves Carneiro[5], Henrique Marcelo Gualberto Pereira[5], Sergio Francisco de Aquino[1] and Maria Elvira Poleti Martucci[4] (1)Post Graduate Program in Environmental Engineering, Federal University of Ouro Preto, 35400-000, Ouro Preto, Minas Gerais, Brazil, (2)Multiuser Laboratory of Molecular Characterization and Mass Spectrometry, Institute of Exact and Biological Sciences, Federal University of Ouro Preto, Ouro Preto, Minas Gerais, Brazil, (3)School of Pharmacy, Federal University of Ouro Preto, 35400-000, Ouro Preto, Minas Gerais, Brazil., (4)Post Graduate Program in Environmental Engineering, Federal University of Ouro Preto, 35400-000, Ouro Preto, Minas Gerais, Brazil., (5)Federal University of Rio de Janeiro, Institute of Chemistry, LBCD-LADETEC, Avenida Horácio Macedo, no. 1281, Polo de Química, Bloco C, Cidade Universitária, Rio de Janeiro, RJ 21941-598, Brazil

The occurrence of organic microcontaminants in aquatic environments has raised environmental concern due to their persistence, widespread distribution, and potential adverse effects on ecosystems and human health. A wide range of organic contaminants is present in the environment, and their determination is a first step toward their monitoring, control, and risk management. To address this, different sample preparation techniques, including solid-phase extraction (SPE), liquid-liquid extraction (LLE), and combined SPE-LLE, were assessed and optimized for the extraction of multi-class organic contaminants from water samples. The target analytes included pharmaceuticals (betamethasone valerate, caffeine, dexamethasone, diclofenac, fluconazole, prednisolone), pesticides (acephate, difenoconazole, tebuconazole, thiamethoxam), and per- and polyfluoroalkyl substances (PFAS). The SPE procedure, conducted using a Strata-X polymeric cartridge, demonstrated superior performance compared to LLE and the combined SPE-LLE approach, providing broader applicability, higher recoveries, and improved operational practicality for multi-class analysis. Therefore, the optimized SPE method was validated using liquid chromatography coupled to high-resolution mass spectrometry (LC-HRMS) and demonstrated acceptable selectivity, precision, repeatability, reproducibility, recovery, sensitivity, with detection limits compatible with trace-level environmental monitoring (< 0.01 μg L-1 and 1 μg L-1) and matrix effects did not compromise analyte identification criteria. This method was applied to surface water samples collected in the Metropolitan Region of Belo Horizonte (Brazil). The sampling was performed at 12 sites over four sampling periods between 2024 and 2025. The LC–HRMS analysis revealed the presence of pharmaceuticals, agrochemicals, and PFAS in surface water samples, providing evidence of the occurrence and

distribution of emerging and legacy environmental contaminants in the studied region. Among the evaluated analytes, diclofenac, fluconazole, tebuconazole thiamethoxam, as well as PFAS, were frequently detected, indicating the widespread presence of emerging and legacy environmental contaminants. Overall, our results enhance current knowledge of the occurrence of environmental contaminants in Brazilian surface waters, particularly pharmaceuticals and agrochemicals, and demonstrate the applicability of a fit-for-purpose analytical method for environmental monitoring.

Disclaimer/Disclosure: This work was supported by Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), grant number 407063/2023-4

4.11.P-We164 Contaminants of Emerging Concern (CEC's) in the Water Supply System of uMngeni–uThukela Water (UUW): A System-Wide Risk Assessment

Zamansele Mhlambi[1], Vhahangwele Masindi[2], Kagiso Komane[2], Florence Raisebe[3] and Mathlodi Mathye[2]
(1)uMngeni-uThukela Water, (2)CSIR, (3)independent

Contamination of water resources by CEC's is of concern to water utilities. Mainly due to it's ubiquitous properties, undocumented nature of their toxicity, to a larger extent, posing risks to consumers. Hence calling for pragmatic ways to manage them for the benefit of the environment and consumers. The above reasons are why this study explores, the extent and occurrence of CEC's in the operational area of UUW.

Samples were collected from water and wastewater treatment plants in KZN. Samples were analysed in the laboratory, following standard methods, such as the Gas Chromatography-Time-of-Flight Mass Spectrometry (GC-TOF-MS) with targeted and non-targeted capabilities for aqueous matrices characterizations. The digital compound microscope was used for the identification of microplastics with their functional groups ascertained using Fourier Transform Infrared Spectroscopy.

Microplastics (MPs) were predominant in all sites and samples with varying properties and exposure extent based on prevailing compounds, denoting high risk of toxicity. Size class ranges were < 5 to > 1000 µm, size range of >1 to <5 µm were most abundant in all sites. However, particle sizes of <5 µm predominated 40 – 60% of particles present in wastewater works (WWWs), whilst 45 – 65% in drinking water treatment plants (DWTP) and freshwater. Across all samples, particle size (class) ranging from 100 – 1000 µm registered 5 – 10%. As reported in the size, the number of particles detected varied, with a wide particle detection range 1 to 173,03 particles/L. WWWs particle size concentrations ranged from 8,050 to 105,838 particles/L, WWs from 13,400 to 173,030 particles/L and river particle size concentration ranged from 1,280 to 77,000 particles/L. The detected MPs exhibited various shapes, including near-spherical, irregular, and fragmented forms. In terms of colour, MP's were detected in a variety of colours, black, blue, yellow and red. Pharmaceuticals and persistent organic pollutants (POP's) were detected in both WWs and WWWs. Chlorinated and brominated aromatics were detected from two sampling sites indicating potential pollution of halogenated disinfection by-products or industrial runoff.

Micro-sized microplastics and CEC's are present in raw water & WW, denoting a risk in water provision especially for the studied sites. Their composition varies significantly denoting higher risk in water provision hence validating high potency of both human and environmental exposure.

Disclaimer/Disclosure: Study is in collaboration with Council for Scientific and Industrial Research (CSIR)

Environmental Forensics: Advances, Applications and Case Studies

4.12.P-Tu253 Chemical Detective Stories: Using Environmental Forensics To Tackle Urban Runoff Pollution

Kelly Moran[1] (1)No Affiliation

In the mid-1990s, new regulatory requirements and widespread aquatic toxicity in creeks receiving urban runoff prompted Northern California government agencies to jointly pursue environmental forensics investigations aimed at identifying cost-effective water quality protections. Working on a contaminant-specific basis, they prioritized pollution prevention over discharge treatment - a novel approach at the time. Their process began with identifying widespread true contaminant sources (e.g., products, air emissions), then developing contaminant-specific conceptual models to identify pathways for contaminant release into urban runoff. These models drew on the still-developing field of urban runoff transport, incorporating insights such as the critical role of directly connected impervious surfaces. Simplified materials flow assessments then identified major contaminant sources - including previously unknown ones (e.g., copper in vehicle brake pads, zinc in tires) - and dispelled persistent myths (e.g., outdoor structural pest control by professional applicators, not lawn and garden pesticides, was found to be the primary source of insecticides in urban waterways). Where a strong weight of evidence was needed to support regulatory action, initial assessments were augmented with tightly scoped follow-up studies to more accurately estimate the relative contributions of specific sources (e.g., controlled wash-off measurements of pyrethroids from impervious surfaces, watershed modeling of brake pad wear and other copper sources). These forensic investigations have since reshaped laws, regulations, and industry practices. A copper study led to legislation in multiple states phasing out copper and limiting other contaminants in vehicle brake pads; a pyrethroids study prompted the California Department of Pesticide Regulation to adopt regulations controlling outdoor applications.

4.12.P-Tu254 Use of High-Dimensional Data To Identify Spatial Distribution and Bioaccumulation Patterns of Heterocyclic Aromatic Compounds in Lake Erie Fish

Nipuni N Vitharana[1], Thor Halldorson[1], Brett Paddock[1], Thane Tomy[1], Chris Marvin[1], A. T. Fisk[1], C. E. Heuvel[2] and Gregg T. Tomy[1] (1)Centre for Oil and Gas Research and Development (COGRAD), Department of Chemistry, University of Manitoba, Winnipeg, Manitoba, (2)Great Lakes Institute for Environmental Research (GLIER), University of Windsor, 401 Sunset Avenue, Windsor, ON N9B 3P4

Hetero-polycyclic aromatic compounds (HPACs) are a subclass of polycyclic aromatic compounds (PACs), a well-known group of environmental pollutants. Although HPACs share structural similarities with common PACs, resulting in comparable environmental behavior and toxic properties, these compounds have received less attention due to challenges such as isomeric complexity and limited availability of analytical standards. The increased polarity introduced by heteroatoms such as N, O, and S makes these compounds more bioavailable to aquatic organisms compared with their homocyclic analogues. In this study, muscle tissues from Lake Erie fish were analyzed for a comprehensive suite of 105 targeted analytes, including both homocyclic and heterocyclic PACs. Four fish species representing different habitats and feeding strategies were collected from the three

main basins of Lake Erie, eastern, central, and western, and the spatial distribution of PACs was examined. Total (∑) PAC concentrations ranged from 0.6 to 490 μg/g lipid weight across all samples, with the highest levels observed in the western basin. Multivariate analysis revealed distinct basin- and species-dependent clustering. Hierarchical cluster analysis further indicated enrichment of brominated HPACs in the central basin, particularly in its western region. To assess bioaccumulation patterns, seven fish species collected from the western basin were analyzed. Redundancy analysis and trophic magnification factor analysis confirmed that habitat-specific exposure, rather than trophic position, is the primary driver of HPAC contamination in Lake Erie biota. The chemometric analysis revealed that HPACs exhibit more distinct environmental distributions of PACs compared to homocyclic compounds.

Disclaimer/Disclosure: This work was supported by a Natural Sciences and Engineering Research Council Discovery Grant to GTT (Grant number: RGPIN-2024-04947) and ATF (RGPIN-2020-05500) and a University of Manitoba Graduate Fellowship to NNV.

4.12.P-Tu256 Chemical Tracer-Based Assessment of Pollution Sources in Biscayne Bay and Its Tributaries, a Heavily Urbanized Estuarine System

Daniel Omana[1], Kassidy Troxell[1], David Hajiyev[1], Eden Fergiev[1], Luis Bordin[1], Maria Guerra de Navarro[1] and Piero Gardinali[1] (1)Florida International University

Biscayne Bay, a critical ecological resource and economic driver in South Florida, has been increasingly pressured by surrounding urbanization. Excess nutrient inputs, particularly phosphorus, have contributed to eutrophication and declining water quality in North Biscayne Bay (NBB), resulting in seagrass loss, hypoxic events, and fish kills (2020, 2021, 2022, and 2024). However, identifying and differentiating the point and nonpoint sources responsible for these nutrient inputs remains a significant management challenge. This study applied source-specific organic chemical tracers to identify pollution sources contributing to nutrient enrichment throughout NBB and its tributaries. Surface water samples were collected from 61 sites across the watershed during the 2026 dry and wet seasons (n = 244). Nutrient analyses were conducted at the Florida International University NELAC-certified CAChE Nutrient Analysis Core Facility following EPA methods. Measured parameters included dissolved inorganic nutrients (NO_2^-, $NO_3^- + NO_2^-$, NH_3/NH_4^+, and soluble reactive phosphorus), total phosphorus (TP), total nitrogen (TN), and chlorophyll a. A targeted analytical method comprising 31 source-specific chemical tracers was developed to distinguish wastewater, agricultural, and urban runoff influences. Chemical tracers were quantified using online solid-phase extraction coupled with heated electrospray ionization high-performance liquid chromatography tandem mass spectrometry (SPE-HESI-HPLC-MS/MS) on a Thermo Scientific Altis Plus triple quadrupole mass spectrometer and processed using TraceFinder 5.1 software. Preliminary results identified nutrient hotspots throughout the watershed and linked them to characteristic pollution source signatures. Wastewater influence was indicated by the presence of sucralose, caffeine, and carbamazepine, with sucralose concentrations ranging from 63.8 to 3,231 ng/L. Agricultural inputs were identified through herbicides including atrazine, metolachlor, alachlor, and associated transformation products, while urban runoff contributions were characterized by the detection of 6PPD, 6PPD-quinone (6PPD-Q), and prometon. The combined use of nutrient measurements and source-specific chemical tracers enabled the identification of pollution hotspots and dominant pollution sources across the NBB watershed. These findings provide a framework for targeted management actions aimed at reducing nutrient loading and improving water quality in Biscayne Bay.

4.12.P-Tu257 Integrating Mixing and Unmixing Methods for PAH Source Identification in Urban Waterway Sediments

Erin Warlow[1], Raghav Narayanan[1], Jessica Goin[1], Brenden Covert[1], Miriam Mathew[1] and Cristin Messerschmidt[1] (1)Anchor QEA LLC

Multivariate statistical methods are widely used in environmental forensics to identify independent contaminant sources and quantify their contributions in environmental samples. Unmixing-based methods can separate out likely sources from environmental sample data. Mixing-based methods can compare combinations of known sources to environmental mixtures to determine the best fit and proportions of individual sources.

This presentation offers a case study where both mixing and unmixing methods were used in tandem to assess polycyclic aromatic hydrocarbon (PAH) sources in sediment at a contaminated urban waterway. The authors first developed a conceptual site model (CSM) incorporating site history, known PAH sources, and fate and transport studies. An unmixing-based approach was used to independently identify the PAH signatures that explained most of the variance in the entire sediment dataset. These signatures aligned well with known sources, reinforcing confidence in the CSM. A mixing based approach was then used on individual PAH samples to determine the relative proportions of the various PAH sources. Further, the CSM indicated that some subareas of the waterway also contained local PAH sources. Incorporating these local sources into the mixing based approach improved understanding of PAH distributions within the subareas of the waterway and determined the proportions of various PAH sources to individual environmental samples.

This presentation will provide a strong example of how integrating multiple statistical approaches can help improve contaminant source identification in sediments. It will also highlight the critical role of a CSM, including understanding site-specific knowledge in mixing model development and strengthening confidence in statistical interpretations.

4.12.P-Tu258 Evaluating Necrophagous Blow Fly Larvae as an Alternative Matrix for Post-Mortem Opioid Detection Using a Rainbow Trout Model

Tyler Dow[1], Denina Simmons[1], Hélène LeBlanc[1], Theresa Warriner[1] and Meghana Augustin[1] (1)Ontario Tech University

Conducting post-mortem toxicological analysis becomes challenging in forensic investigations, particularly when the remains are discovered in an advanced stage of decomposition, making traditional toxicological samples unavailable or unreliable. In such cases, collecting and analyzing insects that have been feeding on the body shows promise as an alternative method of detecting drugs in cadavers. However, a lack of standardized protocols in forensic entomotoxicology has slowed the field's growth and acceptance as a reliable source of forensic evidence. A comprehensive methodology must be developed and standardized to strengthen its legitimacy as a valuable forensic tool.

Currently, post-mortem spiked animal organs are commonly used for method development because they are easy to prepare and inexpensive. However, as post-mortem organs are not living, they do not metabolize drugs, which limits the accuracy and real-world relevance of these results. The use of a live-animal model, where drugs are administered via injection ante-mortem, represents a more realistic scenario as compounds undergo

metabolism.

Our study aims to develop and validate a reliable analytical method to detect opioid compounds and their primary metabolites in blow fly larvae (Phormia regina) using liquid chromatography–tandem mass spectrometry. We have implemented a live-animal model using rainbow trout (Oncorhynchus mykiss) exposed to morphine or fentanyl prior to euthanasia. Decomposing trout carcasses serve as biologically relevant substrates for insect rearing, ensuring realistic exposure to both parent compounds and metabolites. Collected larvae will be analyzed as positive controls to optimize the methodology, which will be further validated by analyzing archived forensic casework samples. Collected tissues will also be analyzed to better characterize how morphine and fentanyl are metabolized in adult rainbow trout and Phormia Regina larvae, and how their primary metabolites compare to those in mammalian species.

This work will contribute to the limited existing literature and application of forensic entomotoxicology in real-world casework and, through its utilization, help investigators and pathologists determine whether drugs were present in an individual's body at or near the time of death.

Environmental Radioactivity: Advances in Biogeochemistry, Ecotoxicity and Ecological Risk Assessment

4.13.T-01 Predictive Environmental Risk Assessment for the Deployment of Small Modular Reactors: Integrating Multi-Pathway Modeling and Source Term Screening

Langping Wu[1], George Alipanopoulos[2], Rina Parker[1] and Don Hart[1] (1)Egis Group, (2)EGIS Group

In Canada, the shift toward advanced nuclear technologies is exemplified by the planned deployment of Small Modular Reactors (SMRs), which introduce distinct reactor physics compared to conventional, heavy-water moderated Canadian Deuterium Uranium units. SMRs utilize different designs such as light water and enriched uranium fuel, altering the specific radionuclide inventory, waste profiles, and atmospheric and waterborne emissions. This fundamental design shift necessitates an evolved approach to predictive ecological and human health risk assessments to ensure robust environmental protection.
The study addresses the challenge of ensuring that environmental risk assessments (ERAs) remain scientifically defensible and protective when applied to SMR technologies whose radionuclide emissions differ from those of conventional Canadian nuclear reactors. For this study a predictive ERA for the deployment of a commercial boiling water SMR design was supplemented with detailed characterization and screening of radiological emission sources. Atmospheric emissions through the reactor's active ventilation system were subjected to a rigorous screening evaluation to identify constituents of potential concern. This screening estimated the relative contribution of each radionuclide to public dose, retaining radioisotopes for detailed modeling that accounted for nearly 99% of total airborne dose. The screening approach allows for exclusion of certain low-impact radionuclides which are predicted to be emitted from SMRs but are not covered in the radionuclide inventory considered in the Canadian Standards Association N288.1 Guidelines.
Exposure and transport modeling were conducted using the IMPACT™ Model, a commonly utilized pathways modelling tool for the nuclear industry. This tool simulated radionuclide behavior across complex atmospheric, terrestrial, and aquatic pathways to assess risks to a diverse suite of human and ecological receptors.

IMPACT™ played a vital role in calculating incremental doses by modeling radionuclide cycling through the biosphere and accounting for progeny buildup. The modeling demonstrated that predicted incremental radiation doses for all human and ecological receptors represent small fractions of established regulatory limits and ecotoxicity benchmarks. The results of the predictive ERA provide important insight into new radionuclides for effluent and environmental monitoring that will be used to provide information to future ERAs.

4.13.T-02 Influence of Radiation on Metal Bioaccumulation in Mammals Exposed to Metal Mixtures Present in Canadian Regions With Nuclear Facilities

Louise-Emmanuelle Paris[1], Debra Hausladen[1] and Adrienne Ethier[2] (1)Université de Sherbrooke, (2)Canadian Nuclear Safety Commission

Main goal: The project aims to support risk assessment by determining whether combined exposure to metals/radionuclides and ionizing radiation poses an additional risk to mammals, while contributing to improved environmental risk management in regions hosting nuclear facilities. A key strength of the project is that it links fundamental ecotoxicology with federal environmental regulations.

Study Part 1: The Canadian Nuclear Safety Commission has identified the need to better characterize background metal concentrations in Canadian regions where uranium mining and nuclear power plants are prominent, in order to accurately assess the cumulative impacts of anthropogenic inputs associated with nuclear activities. The first part of the project involved building a database of >100,000 entries of background metal concentrations across three regions of interest, and conducting spatial and statistical analyses of their occurrence in soil, sediment, and surface water. These analyses led to the derivation of proposed interim guidelines and examined the influence of surficial geology and watershed characteristics on metal concentrations.

Study Part 2: In ecotoxicology, the combined effects of ionizing radiation and metal toxicity remain poorly documented. Mammals are the most radiosensitive taxon, and ingestion typically represents their primary exposure pathway to metals in risk assessment contexts. A significant proportion of mammals in the regions of interest have plant-based diets. The second part of the project involves reproducing representative metal mixtures identified in Part 1 and exposing plants in vivo to these mixtures in combination with radiation. The goal is to assess the effects of radiation on metal bioaccumulation and distribution within plant tissues that may be consumed by mammals.

Study Part 3: Building on these results, metal mixtures and radiation will be tested in vitro using mammalian intestinal cell cultures to evaluate the effects of radiation on the intestinal barrier's permeability to metals.

Study Outcome: If radiation exposure results in increased bioaccumulation of metals in plants consumed by mammals, as well as increased permeability of the intestinal barrier to metals, this would highlight the need for improved integration of these interactions into environmental risk assessment frameworks, namely for the Canadian Nuclear Safety Commission.

4.13.T-03 Health, Growth and Reproductive Success of Mice Exposed to Environmentally Relevant Levels of Different Types of Organically Bound Tritium Over Multiple

Generations

Marilyne Stuart[1] (1)Canadian Nuclear Laboratories (CNL)

The goal of this study is to improve understanding of the dosimetry and health effects associated with different forms of organically bound tritium over multiple generations and to identify relevant biological endpoints in different tissues. The study consisted of a control group and three treatment groups each containing 40 mice (20 males and 20 females) of the CBA/CaJ strain that were continuously exposed to tritiated amino acids (via drinking water or via the feed) or to a tritiated fatty acid (via the feed). Exposures started when the parent generation was 7 weeks old. Breeding was at 10 weeks of age, and the study was concluded after three breeding cycles.

Internal tritium dose rates increased faster when tritiated amino acids were delivered through the feed compared to through the drinking water. Similar internal tritium dose rates were obtained when mice received tritiated amino acids and the tritiated fatty acid via the feed; however, males tended to display higher internal tritium dose rates in the amino acid group, while, for mature females, it tended to be the opposite. Gamma-H2AX foci were more numerous in exposed groups compared to the control group. Erythrocyte micronucleus frequency was not affected by the exposures. Changes in liver and muscle fatty acid composition were noted in response to the exposures. Exposure groups had a tendency to display higher body weights compared to controls. Changes were also noted in hematology and blood chemistry parameters, with differences depending on exposure type and sex.

Based on the endpoints measured on four generations of mice, there is no indication that the consumption of organically bound tritium (at dose rates up to 4 x 10-4 mGy/day) negatively affects health, growth and reproductive fitness. Biological changes are, however, noted at such exposure levels.

Disclaimer/Disclosure: The author list is as follows:

A Festarini, L. Bertrand, J. Arnold, G. Gayda, F. Beimers, C. Corris, L. Carty, A. Shkarupin, D. Deng, P. Shreeves, S. Jarron, J. Virgin, J. Sparling, S. Wentzell, G. Chen, A. Hancock, K. Sims, S-B. Kim and M. Stuart.

4.13.T-04 Moss as a Bioindicator of Atmospheric Radium Deposition in New Brunswick, Canada

Nathanael Vautour[1], Mia Courville-Todorov[2], Mélanie Jean[2] and Olivier Clarisse[1] (1)Département de chimie et biochimie - Université de Moncton, (2)Département de biologie - Université de Moncton

Radium (Ra) is a naturally occurring radionuclide, with its most persistent isotope, 226Ra (half-life: 1602 years), representing a long-term environmental concern. Anthropogenic activities such as mining and oil and gas production can enhance the mobilization of radium from geological sources to surface environments. Despite this, its environmental behaviour and ecological implications—especially at low levels—remain poorly characterized, partly due to analytical challenges in measuring ultra-trace concentrations.
This study presents a novel, rapid, and reliable method for quantifying 226Ra in moss, and applies it to a large-scale, high-resolution biomonitoring survey across New Brunswick, Canada. Mosses, which lack root systems and primarily acquire nutrients from atmospheric deposition, are well established bioindicators of airborne

contaminants.
A total of 205 sites were sampled during the summers of 2021 and 2022, targeting three common moss species (Pleurozium schreberi, Hylocomium splendens, and Hylocomiadelphus triquetus). Spatial patterns of 226Ra deposition were quantified across the province, with concentrations ranging from 6 to 410 fg g^{-1} (mean: 40 ± 40 fg g^{-1}). The influence of environmental factors (including precipitation, pH, lithology, forest type, proximity to roads, and anthropogenic activities) and species-specific uptake was evaluated.
Our results support the applicability of moss-based monitoring for radionuclides and demonstrate that the ICP Vegetation protocol—widely used for trace metals—can be extended to radium. This work provides a cost-effective approach for assessing atmospheric deposition of naturally occurring radionuclides and contributes to improving environmental monitoring frameworks relevant to risk assessment.

4.13.T-05 Relevance of Sediment and Dietary Ingestion for Radium-226 Accumulation in an Estuarine Sentinel Bivalve

Sarah Donaher[1], Annelise Gonzales[2], Brian Powell[2] and Nicole Martinez[2] (1)University of Tennessee Knoxville, (2)Clemson University

Filter-feeding organisms such as bivalves are valuable as biomonitors because they can accumulate contaminants from aqueous, sediment, and dietary sources. This study explored the signatures of two uptake pathways (sediment and dietary) for the accumulation of radium-226 (226Ra) in the soft tissue of an estuarine mussel, Geukensia demissa. After 7 days of exposure to a 55.5 kBq kg-1 226Ra radiolabeled sediment, we observed preferential accumulation in the mussel labial palps, the tissue group associated with particle discrimination, with concentrations 7.4x higher than controls. We also compared measurement of the whole body 226Ra activity through two methods: a destructive elemental analysis via inductively coupled plasma mass spectrometry (ICP-MS) and a nondestructive, live-animal radioanalysis via high purity germanium (HPGe) detection. Results between these two methods were generally in good agreement during the uptake phase, but HPGe measurements overestimated whole body activity relative to ICP-MS measurements in the depuration phase. Finally, soft tissue 226Ra concentrations in mussels after feeding on a 226Ra radiolabeled algae source were highly dependent on the length of time the algae were exposed to 226Ra and were highest in organ groups associated with digestion. This study demonstrates preferential tissue-specific uptake which varies by exposure source for 226Ra accumulation in an estuarine sentinel species. These results can improve environmental radiological risk assessments by exploring methodology and modeling considerations relevant for developing multi-pathway toxicokinetic models.

4.13.T-06 Moving Beyond Single Stressors: The State of Science for Multi-Stressor Assessments Incorporating Radionuclides and Recommendations for Environmental Risk Assessment Approaches

Linda Campbell[1], Robert J Thacker[1], Hemendra Mulye[2], Samantha Longo[2] and Maria Yu[2] (1)Saint Mary's University & EGCB Canada, (2)Canadian Nuclear Safety Commission

We evaluated the current state of science regarding multi-stressor effects assessments incorporating radionuclides in aquatic and terrestrial receiving environments near Canadian nuclear power plants and uranium mining and milling operations. We conducted a systematic and iterative literature review of academic databases, institutional repositories, and regulatory frameworks, creating a curated corpus of over 500 sources, focused on

priority radionuclides (e.g., tritium, uranium isotopes, radium-226, cesium-137) and non-radiological co-stressors such as but not limited to temperature, metals, organic and inorganic pollutants. The literature consistently demonstrates that interactions between radionuclides and co-stressors are highly context-dependent and frequently non-additive, commonly resulting in the synergistic amplification of biological impacts. This presents a significant challenge for current environmental risk assessment (ERA) approaches, which remain largely grounded in single-stressor assumptions or additive models and which independently assess chemical and radiological effects under normative assumptions. Advancing multi-stressor ERAs requires transitioning from acute, high-dose single-stressor testing to chronic multi-factor research. A clear roadmap to harmonize physical/chemical and radiological risk assessments is needed, and we recommend that multi-stressor frameworks focus on: (I) problem formulation using functional ecological groups, (II) dynamic exposure and transfer modelling, (III) mechanistic effects assessment, and (IV) risk characterization through adaptive management. Integrating conceptual scaffolds like Adverse Outcome Pathways (AOPs) and Aggregate Exposure Pathways (AEPs) will be crucial to linking molecular initiating events and ecosystem-level impacts, and to help to refine recommendations specific to each receiving environment. By explicitly taking into consideration the inherent uncertainty of natural environments, these findings can be used to modernize environmental risk assessment approaches and safeguard complex ecosystems from potential cumulative risks.

Disclaimer/Disclosure: CNSC Contract No. 3000802612 to EGCB Canada.

Environmental Radioactivity: Advances in Biogeochemistry, Ecotoxicity and Ecological Risk Assessment

4.13.P-Th122 Effect of Key Chemical Water Parameters on Radium-226 Bioaccumulation by a Freshwater Microalga

Flavie Desreac[1], Claude Fortin[1] and Anne Cremazy[1] (1)National Institute for Scientific Research (INRS)

Radium-226 is a radioactive isotope produced by the decay of uranium-238, which is naturally present in the bedrock. Consequently, it can be found in mine tailings, leading to its release into surface water. Nevertheless, the bioaccumulation of Ra-226 in aquatic organisms, particularly in relation to physicochemical variations in the environment, remains a subject that has been poorly studied. Water quality parameters (e.g., pH and concentration of organic matter) have the capacity to influence the speciation and bioavailability of Ra-226, thereby affecting its potential transfer within the aquatic food chain. Thus, the objective of this study is to evaluate the effect of various water chemistry parameters of the environment (major cations, organic matter, and pH) on the bioaccumulation of Ra-226 by a freshwater microalga (Chlamydomonas reinhardtii). In the lab, microalgae were exposed to a constant dose of Ra-226 (50 Bq/L, 5.98e-12 M) for 72 hours, at varying calcium concentration (from 0.05 to 2 mM), magnesium concentration (from 0.05 to 1.5 mM), pH (from 5.5 to 7.9), and dissolved organic matter concentration (from 0 to 15 mg DOC/L) (each parameter was varied separately). The results demonstrate a significant decrease in Ra-226 bioaccumulation with increasing Ca concentration, indicating strong competition between Ca2+ and Ra2+ for cellular uptake pathways. An increase in Mg led to a substantially smaller decrease in Ra-226 bioaccumulation. The increase of H+ ions (i.e. decrease in pH) resulted in a modest decrease in Ra-226 bioaccumulation; thus, this effect appears to be physiological rather than a competitive effect. Finally, dissolved organic matter exerted no measurable effect on Ra-226 bioaccumulation,

likely due to insufficient complexation of Ra-226 across the tested conditions. Consequently, Ca appears to be the primary regulator of Ra-226 bioavailability in C. reinhardtii under the tested conditions. Accordingly, in the subsequent phase of the project, the intracellular fate of Ra-226 and newly accumulated Ca-45 will be compared to confirm that these elements share similar intracellular handling mechanisms.

4.13.P-Th123 The Effect of Calcium on Radium-226 Bioaccumulation, Dose Rates, and Toxicity to Fingernail Clams (Sphaeriidae)

Catherine Proulx[1] and Richard Goulet[2] (1)University of Ottawa; Kilgour & Associates Ltd., (2)Canmet-MINING, Natural Resources Canada, Ontario, Canada

The objective of this study was to investigate the effect of calcium on 226Ra bioaccumulation and toxicity to fingernail clams (Sphaerium striatinum). Controlled laboratory experiments were performed, exposing clams to waters varying in calcium concentrations (0.9, 7, 35, 70 mg L-1) dosed with six nominal 226Ra activity concentrations between 0.5 and 50 Bq L-1 and a control. Bioaccumulation was measured in soft tissue and shell, and dose rates were estimated using multiple approaches that varied assumptions regarding water and sediment occupancy, as well as sediment partitioning. Increasing calcium reduced the removal of ^{226}Ra from exposure solution, resulting in higher dissolved concentrations due to decreased sorption. ^{226}Ra accumulated in both soft tissue and shell, with greater partitioning to shell. Bioaccumulation increased with exposure, while calcium modified uptake patterns. Correspondingly, dose rates increased with exposure and were dominated by waterborne pathways, with minimal contribution from sediment under observed conditions. Dose rates were often above screening benchmarks, suggesting potential ^{226}Ra toxicity. Toxicity responses varied among endpoints: survival, growth, and reproduction declined with increasing ^{226}Ra, while behavioural responses were more variable. Calcium modified these responses, with evidence of increased sensitivity at lower ^{226}Ra concentrations under elevated calcium conditions. These patterns reflect competing biological and geochemical mechanisms. Increased calcium likely reduced ^{226}Ra uptake through competitive interactions at biological membranes while simultaneously increasing dissolved ^{226}Ra concentrations by limiting sorption to mineral phases, thereby sustaining aqueous exposure.

4.13.P-Th124 Bioaccumulation and Fate of Radium-226 in Lymnaea stagnalis

Léna Guimard[1], Luana Hainzenreder Bauer[2], Maikel Rosabal[2], Claude Fortin[1] and Anne Cremazy[1] (1)National Institute for Scientific Research (INRS), (2)University of Quebec in Montreal (UQAM)

In Canada, mining can mobilize naturally occurring radionuclides. Among these, radium-226 (^{226}Ra) is of particular concern due to its long half-life (1,600 years), its potential for bioaccumulation, and its radiotoxicity. To better understand the effects of this radionuclide on aquatic organisms, we characterized its bioaccumulation and elimination in Lymnaea stagnalis, a pulmonate snail common in Canadian fresh waters. To gain insights on the toxicity and detoxification pathways of this element, its subcellular distribution was also assessed. It was expected that this calciphilous organism would bioaccumulate 226Ra to a large extent in its calcium carbonate shell and detoxify it primarily via the hepatopancreas (a detoxification organ). At the subcellular level, this class A metal was expected to be found primarily in the mitochondria (sensitive fraction) and the granules (detoxified fraction) because they have large amounts of oxygen-donor binding groups. To test these two hypotheses, we conducted 72-h exposures to aqueous 226Ra (100 Bq/L) with juveniles of L. stagnalis, with one test extended for 96 h in 226Ra-free water to measure 226Ra elimination rate. We then measured: 1) the bioaccumulation and

elimination of 226Ra in various tissues (shell, mantle, hepatopancreas, foot, digestive tract) and 2) the bioaccumulation of 226Ra in various subcellular fractions (granules, debris, mitochondria, microsomes, lysosomes, heat-denaturable proteins, heat-shock proteins). We found that the majority of 226Ra was stored in the shell (non-trophically available) of L. stagnalis and was quickly eliminated by the mantle and the hepatopancreas. These observations are in line with the substantial calcium storage in the shell, the function of the mantle in calcium transportation and the hepatopancreas's role in detoxification. At the subcellular level, 226Ra was found primarily in the mitochondria and granules. Storage in granules highlights a potentially significant detoxification mechanism, while distribution in mitochondria indicates a possible important intracellular target. The findings of this study offer a better comprehension of the mechanisms of accumulation, as well as the potential for trophic transfer of this radionuclide.

4.13.P-Th125 Transforming Radiological Environmental Monitoring: Developing Non-Lethal Proteomic Techniques With Fathead Minnow (Pimephales promelas)

Spencer Hang[1], Erico Oliveira Pereira[1], Theresa Warriner[1], Sharmin Bhaiyat[1], Quinn Eng[1], Kirk D. Atkinson[1] and Denina Simmons[1] (1)Ontario Tech University

With the looming threat of climate change, governments around the world have begun investing in alternative energy sources to replace fossil fuels, with a significant emphasis on nuclear energy. Small modular reactors (SMRs) can replace fossil fuel usage. In addition, they can be used in small, remote communities for electricity generation, desalination, and heating. However, while still novel, there is limited knowledge of the effects that SMRs might have on their surrounding environment. While there is literature on the effects of ionizing radiation to fish, most studies have focused on acute, single-exposure developmental toxicity above 1 Gy, with limited results on the effects of lower levels over long-term, chronic exposures. Our study aims to address this gap in the literature by investigating the effects of ionizing radiation on the proteome of the fathead minnow (Pimephales promelas) at two different exposure levels, 0.05 Sv and 1 Sv. We will sample across multiple tissue types, including mucus, plasma, gill, skin, and muscle. We expect to see changes in protein concentrations associated with reactive oxygen species, pigmentation, and sex hormones. These results can be used to develop non-lethal biodosimetry programs for the environments surrounding SMRs, enabling consistent monitoring while reducing stress on sample organisms and providing additional data for risk assessors.

4.13.P-Th126 Comparative Uptake, Translocation, and Plant Mediated Subsurface Transport of Radionuclides in Soil Columns

Dawn Montgomery[1], Abigail Rowell[1], Nicole Martinez[1] and Brian Powell[1] (1)Clemson University

This work summarizes plant uptake studies at the laboratory and (controlled) field scale. Laboratory-scale column experiments examined the uptake into the grass species Andropogon virginicus as well as its ability to alter the subsurface transport and redistribution of a suite of radionuclides, Tc-99, Cs-133 (stable analog for Cs-135 and 137), Np-137, and U-238 through the use of vegetated and unvegetated soil columns. After an acclimation and initial growth period, a small volume of solution containing all radionuclides was introduced into the columns via Rhizon© pore water sampling tubes. Plants were grown for an additional four weeks before shoots were harvested, and columns were prepared for sampling. Similar controlled field-scale experiments utilized vegetated and unvegetated lysimeters, larger soil columns in an outdoor facility exposed to environmental conditions over a period of several years. Plants were similarly harvested and analyzed for

radionuclide content (Tc-99, Np-237, native Cs-133, and native U-238). Field-scale lysimeter effluent was also collected and analyzed throughout to monitor radionuclide release and migration through the soil columns and to provide insight into differences between vegetated and unvegetated columns.
In general, plant presence led to decreased radionuclide release from the columns and different soil concentration profiles in laboratory studies. Further, notable upward migration for Np-237 and significant Tc-99 accumulation in plant material were observed for laboratory columns. Lysimeter analysis is ongoing, but effluent analysis indicates significant retention and retardation of Tc-99 and Np-237 in vegetated lysimeters compared to those without plants. Overall, this study quantified the influence of several plant-mediated physical and biogeochemical factors that have a significant influence on radionuclide mobility and transport in this complex system, which can be further utilized in future systems or site-specific environmental transport and risk assessment models.

4.13.P-Th127 Bridging Human and Environmental Radiological Protection With the Ecosystem Services Approach

Sarah Donaher[1], Phil Kruse[2], Jeffrey Whicker[3], Karine BEAUGELIN-SEILLER[4], Adrienne Ethier[5], Cameron Jeffries[6], Analia Canoba[7] and Nicole Martinez[8] (1)University of Tennessee Knoxville, (2)EDF Energy, (3)Retired, (4)French Authority of Nuclear Safety and Radioprotection, (5)Canadian Nuclear Safety Commission, (6)South Australian Medical Imaging, (7)Autoridad Regulatoria Nuclear, (8)Clemson University

Ecosystem services, the benefits people derive from nature, provides a conceptual structure by which to explicitly characterize and protect the coupled human-nature relationships which are central to human well-being, the integrity of ecosystems, and sustainable development. In this presentation, we describe a framework to bridge human and environmental radiological protection (RP) by assessing impacts to ecosystem goods and services. As operationalization of an ecosystem services approach is a notable challenge for RP implementation, we discuss Anthophila (bees) as a model clade for demonstrating how this approach may contribute to the integrated protection of people and the environment across geographies, cultures, and exposure scenarios. Assessing the impacts of radiological contamination and associated decision-making on ecosystem services has the potential to bridge human and environmental RP through adoption of a sustainable development mindset, enhanced stakeholder engagement, and improved decision-making. We describe a conceptual model to combine the ecosystem services approach with RP and demonstrate its application to a hypothetical existing exposure situation using bees as a model clade of species.

4.13.P-Th128 Environmental Monitoring of Radionuclides During a Coal-to-Fusion Energy Transition at the Bull Run Fossil Plant

Elle Street[1], Pascal Dumont[2], Delaney Bellis[1], Michael Ratliff[1] and Sarah Donaher[1] (1)University of Tennessee, Knoxville, (2)Type One Energy

The transition from legacy fossil fuel infrastructure to next-generation energy systems presents environmental challenges and opportunities. The Tennessee Valley Authority (TVA) Bull Run Fossil Plant in eastern Tennessee is a former coal-fired power plant which ceased operations in 2023 and is currently undergoing redevelopment for Type One Energy's "Infinity One" fusion stellarator project. This change in site use necessitates environmental monitoring to evaluate residual impacts from historical coal combustion and establish baseline conditions prior to fusion-related activities. We present results from the first six months of an

environmental monitoring program conducted across the Bull Run site and surrounding areas. Sampling efforts targeted radionuclides associated with coal combustion residuals such as uranium-238, thorium-232, and radium-226 in surface water, groundwater, and soil. We also measured tritium, a major fuel source for nuclear fusion, in surface water, groundwater, and air to establish baseline conditions. Spatial and temporal trends are evaluated to characterize the extent of the environmental "fingerprint" associated with operations at the coal-fired plant, identify possible transport pathways, and distinguish anthropogenic signatures from natural variability. Radionuclide analyses provide insight into environmental baselines, supporting future differentiation between background radiation and any perturbations associated with fusion facility development.

Fate and Effects of Metals: Biogeochemical Perspective

4.14.P-We176 Iron Modulation of Bismuth Subcellular Fate and Toxicity in the Green Alga Chlamydomonas reinhardtii

Jian Zhao[1], Maikel Rosabal[2] and Claude Fortin[1] (1)Institut National de la Recherche Scientifique (INRS), (2)University of Quebec in Montreal (UQAM)

Bismuth is widely used in consumer products such as cosmetics, pharmaceuticals, and pigments. Meanwhile, demand for bismuth is increasing rapidly in industrial sectors, including lead-free ammunition, brass components for potable water systems, glass, free-cutting alloys and fire-safety devices, where it is used as a substitute for lead. However, understanding of its behavior and bioavailability in aquatic environments remains limited. This research aims to explore how changes in iron levels influence the response of the freshwater green alga Chlamydomonas reinhardtii to bismuth. In this study, C. reinhardtii is exposed to bismuth for 72 hours under iron-replete (592 nmol/L Fe) and iron-deficient (29.6 nmol/L Fe) conditions. Cell growth rate, extracellular surface adsorption, and intracellular accumulation of bismuth are assessed. Subcellular fractionation is used to identify the major target compartments of bismuth accumulation in algal cells under different iron conditions. We hypothesize that bismuth accumulation and tolerance in algae are modulated by iron levels. Under the iron-deficient condition, vacant high-affinity iron-binding sites on the cell surface may favor surface adsorption of bismuth, while potentially lowering the tolerance threshold of algae to bismuth stress. This study provides key data and new insights for a more comprehensive assessment of bismuth cycling and its potential environmental risks in aquatic systems, which contribute to the safe and sustainable application of bismuth.

Disclaimer/Disclosure: The project was funded by the Fonds de recherche du Québec (https://doi.org/10.69777/370113), the NSERC discovery grant (RGPIN-2025-06704) and the NSERC MIXCHEM CREATE (596176-2025) programs.

4.14.P-We177 Evaluating the Effects of Dissolved Organic Matter, Hardness, and Chloride on the Toxicity of Fluoride to Ceriodaphnia dubia and Fathead Minnow (Pimephales promelas)

Samuel Parker[1], Austin Wilkes[1], Elena Legrand[2], Marie-Christine Simard[3] and Rajat S. Ghosh[4] (1)EHS Support LLC, (2)EHS Support Inc., (3)Rio Tinto, (4)Alcoa Corporation

Dissolved organic matter (DOM) is a core constituent in freshwaters globally. Its importance in mitigating or mediating toxicity is understood for a variety of analytes and constituent groups. Unlike for other toxicity modifying factors (TMFs), little information is known on the role of DOM in mitigating or mediating fluoride toxicity in aquatic organisms. To bridge the gap, acute 48-h survival bioassays were conducted on fathead minnow (Pimephales promelas) and Ceriodaphnia dubia using 16 different synthetic treatment waters to assess the influence of hardness, chloride, and DOM on fluoride ecotoxicity. Chronic, 7-d bioassays were also conducted to assess the importance of inorganic TMFs on fluoride toxicity to C. dubia and P. promelas for four inorganic synthetic water treatments. Inorganic constituent concentrations in synthetic test waters targeted two water hardness conditions: very soft (10.6 mg CaCO3/L) and hard (169.5 mg CaCO3/L) and two chloride conditions: low (0.25 mg Cl/L) and high (64.0 mg Cl/L). Suwannee River NOM II was added to test waters for acute toxicity tests that targeted 0.0, 2.0, 8.0, and 32.0 mg/L DOM, which corresponded to measured mean ± standard deviation dissolved organic carbon (DOC) concentrations, a common proxy for DOM, of 0.0, 1.1 ± 0.1, 3.7 ± 0.1. and 14 ± 0.0 mg/L DOC, respectively. Acute bioassay results indicated that DOM was not an appreciable TMF of fluoride. The relative importance of TMFs was assessed using generalized mixed modeling, which found the relative influence of TMFs on fluoride toxicity to C. dubia and P. promelas to occur as hardness>chloride>>DOC and hardness=chloride>>DOC, respectively. For acute bioassays, 48-hr LC50 varied by a factor up to 3.2 and 2.2 between TMFs treatment for C. dubia, and P. promelas, respectively. For chronic bioassays, 7-d IC25 varied by a factor up to 3.7 and 2.6 between TMFs treatment for reproduction in C. dubia, and growth in P. promelas, respectively. The influence of inorganic TMFs was similar across exposure duration (acute vs chronic), with hardness being the most consistent TMF between bioassays. This study provides additional empirical evidence that hardness and chloride influence fluoride toxicity over DOM and emphasizes the need to account for site-specific water quality conditions when assessing risk to aquatic organisms.

4.14.P-We178 Beavers (Castor canadensis) As Biomonitors of Trace Elements in the Environment: Examples From Industrial, Urban, Rural and Remote Areas in Western and Eastern Canada

Sandor Haas-Neill[1], Melissa Dergousoff[2], Iain Grant-Weaver[3], Glynnis Hood[4], Tommy Noernberg[3], Rick Pelletier[3] and William Shotyk[5] (1)Fountain Pen Health Communications, (2)RCH Resource Management, (3)Department of Renewable Resources, University of Alberta, (4)Augustana Campus, Camrose, University of Alberta, (5)Bocock Chair for Agriculture and the Environment, Department of Renewable Resources, University of Alberta

Beavers (Castor canadensis) have been used for environmental biomonitoring of trace elements (TEs) due to their semiaquatic habits and localized foraging ranges. Their ongoing population expansion in the northern hemisphere combined with increasing industrial development in the same region, presents a growing scientific opportunity to assess environmental impacts on biota. In northern Alberta, Canada, open-pit mining and upgrading of the Athabasca Bituminous Sands (ABS) has raised concerns about TE contamination of wildlife

and traditional Indigenous food sources. Despite extensive environmental monitoring in the ABS region, no systematic studies have assessed TE accumulation in the local beavers. Here, we measured concentrations of 24 TEs in liver, kidney, and muscle tissues of 51 beavers from Alberta. These span industrial, agricultural, and natural landscapes, and the data are compared with beavers from sites in Ontario of no known point sources of metal contamination. Several TEs showed regional variation, but most TE concentrations in Alberta beavers were statistically indistinguishable from Ontario animals. Notably, cadmium concentrations in Alberta beaver kidneys (up to 73.2 mg/kg) were higher than those reported in literature, though not uniquely elevated in ABS regions. Nickel was significantly enriched in kidneys of beavers from northern industrial sites ($p=0.00034$), while vanadium ($p=2.0e-8$) and selenium ($p=0.0096$) were more elevated in beavers from urban than industrial sites. Overall, beavers near bitumen extraction operations showed no consistent or significant increase in TEs compared to those from natural areas, including distant regions. These findings challenge the assumption that ABS activities are major sources of TE contamination in local biota. Instead, they suggest that urban environments may pose a greater TE exposure risk to wildlife. This study provides a critical benchmark for future environmental monitoring and offers valuable context for Indigenous communities assessing risks from traditional food sources.

4.14.P-We179 Metabolic Effects of the Dewatering of the Copper Pit on Salmonidae: Biomarkers and Monitoring Tool Development

Maé VAUTHIER[1], Patrice Couture[1], Valerie Langlois[1], Wijdane Limouni[2] and Alexandre Thibodeau[1]
(1)National Institute for Scientific Research (INRS), (2)University of Quebec in Abitibi-Temiscamingue

Mines Gaspé's site in Murdochville (Gaspé Peninsula, Quebec) has been closed since 1999. It is currently undergoing advanced exploration and development activities by Osisko Metals. The dewatering of the Copper Pit, where water accumulated to a depth of over 180 m, is required to provide access to certain areas of the pit and to carry out technical and geological work, which will lead to techno-economic studies evaluating the potential for mine reopening. This dewatering will require the discharge of large volumes of water into the Porphyre Creek, a tributary of the York River, over an estimated three-year period. This river hosts the Atlantic salmon (Salmo salar), an ecologically, culturally, and economically important species considered vulnerable within this watershed. The objective of this study is to quantify the metabolic impacts of this change in water chemistry on Atlantic salmon and Brook trout (Salvelinus fontinalis) in the York River before, during and after dewatering, and to identify sensitive and relevant biomarkers for the development of environmental monitoring tools. Juvenile fish samples will be collected using electrofishing at impacted and control sites in summer 2026 (baseline conditions), and then in summer 2027 after initiation of pit dewatering. Fish liver and muscle will be assessed for oxidative stress, antioxidant capacity, and mitochondrial metabolism using biochemical assays, complemented by gene expression analyses of key enzymes and metallothioneins via quantitative real-time PCR. The condition index (length-to-weight ratio) will also be used to assess potential indirect effects on somatic growth and energetic status. Preliminary data from 2024 reveal that Atlantic salmon and brook trout caught in the York River downstream of Porphyre Creek (the main effluent from the mine site) exhibited higher concentrations of Cu, Cd, As, Mo, and Zn compared to control sites. However, the toxicological implications for the health and fitness of juvenile salmonids remain unknown. We hypothesize that chronic metal exposure induces oxidative stress and increases metabolic demand in juvenile salmonids, thereby reducing the energetic resources available for growth and physiological performance. This study will provide novel ecotoxicological data in the context of mine dewatering and will contribute to the development of a biomonitoring toolkit

transferable to this and other mining projects located near salmonid streams.

Disclaimer/Disclosure: This study is funded by the Natural Sciences and Engineering Research Council of Canada (NSERC Alliance Advantage Grant, NIP 100796) in partnership with Osisko Metals and the Foundation for Atlantic Salmon Conservation (FASC).

4.14.P-We181 Which Bioavailability Statistic for Arsenic and Lead: Risk Management Implications at a Jarosite-Bearing Mining Superfund Site

Mary Looney[1] and Lynn Woodbury[1] (1)CDM Smith

Bioavailability adjustments are increasingly used at mining-impacted sites to refine estimates of human exposure to arsenic and lead. The in vitro bioaccessibility (IVBA) assay (U.S. Environmental Protection Agency [EPA] Method 1340) provides a validated basis for these adjustments, with measured IVBA converted to relative bioavailability (RBA) for risk assessment calculations. At a mining-impacted Superfund site in the Rocky Mountain region, the arsenic and lead RBA was determined from IVBA measured in multiple samples from mine waste piles across the site, about 100 piles. Lead RBA ranged from 5 to 75% (values below 5% were conservatively set to a 5% floor), and arsenic RBA ranged from 3 to 60%. RBA was highly variable within and among piles, driven largely by jarosite, which sequesters arsenic and lead and lowers their solubility at gastric pH. Maximum arsenic and lead soil concentrations were not correlated with their respective maximum measured RBA; a high concentration does not necessarily indicate high human health risk. Jarosite-group minerals are themselves being studied as an in-situ remediation approach, and the natural jarosite passively mimics engineered remediation.

This variability raises a practical question that guidance addresses loosely: which RBA statistic should represent a pile, an exposure area, or the site when bioavailability is carried into risk and cleanup decisions? Using the site dataset, risk management outcomes were compared under the pile-specific maximum, the pile-specific average, a sitewide aggregate (average and 95% upper confidence limit of the mean [95UCL]), and EPA default RBA values, evaluating how each impacts the number of piles that exceed risk-based action levels. Sample counts per pile were too few to compute pile-specific 95UCLs.

The choice of statistic is itself a consequential risk management decision: sitewide aggregation can mask piles with high bioavailability, while pile-specific maxima are most conservative and expand the remedial footprint. Further, jarosite is metastable and can weather to iron oxides as pH rises or under reducing conditions, but weathering is slow in the semi-arid, oxidizing Rocky Mountain setting; the low bioavailability is likely relatively stable. Because the mineralogy is not permanent, defensible decisions depend both on the statistic selected and on recognizing that pH or redox changes could alter metal speciation and bioavailability over time.

From Detection to Direction: Advancements and Best Practices for the Detection and Quantification of Micro- and Nanoplastics in Complex Media

4.15.T-01 Understanding Implications of Fragmentation Through In-Situ Characterization and Modelling of Weathered Microplastics

Jasmine Hong[1], Olivia Hengelbrok[1], Ranjan Roy[1], Julien Gigault[2], Subhasis Ghoshal[1] and Audrey Moores[1]

(1)McGill University, (2)University of Laval

As plastic debris have become ubiquitous in the aquatic environment, there is an increasing need to understand the implications of environmental transformation on consumer plastics and their additives. Mechanical degradation resulting from mechanisms such as sand abrasion, wave transportation, and embrittlement through oxidation causes the fragmentation of plastic debris to micro- and nanoplastics which have been noted as an emerging contaminant. As such it is crucial to expand our understanding of the impacts of these pollutants as they degrade in order to better inform regulations and policies around existing and novel consumer polymer development.

However, accessing uniform representative microplastics in lab for fate and toxicity testing is complex due to technical and practical challenges, thus novel methods of producing weathered samples are urgently needed. In this work we show an accelerated methodology to produce microplastics that mimic key surface properties of microplastic fragments that are induced via natural weathering processes (Hong et al. ES&T, 2025). The impact of weathering on plastic debris causes a transformation in physicochemical properties which can influence transport, toxicity, and adsorption mechanisms compared to virgin plastics. The production of relevant micro- and nanoplastic models has the potential to allow for more intensive experimental studies on the toxicity, fate, and behaviour of these moieties. Through a combination of cryo-milling, UV radiation, and mechanochemical strategies we were able to successfully capture key surface features modelled after an environmental plastic sample in the artificially weathered microplastic samples.

In another line of research, we explore implications of weathering on heavy metal containing additives in plastic debris. In this work, we present a study exploring the impacts of weathering on released secondary MPs using legacy ocean plastics as our model of interest. Legacy ocean plastic samples can be used to understand the long term effects of weathering on additive release as a way to gain insight into the transport of additives. We extracted MPs formed through the breakdown of the surface of macroplastics and compared their composition to that of the bulk-macroplastic fragments. Through ATR-FTIR, DSC, ICP-MS and STEM-EDX analysis, we were able to identify variations between the bulk and fragmented microplastics from legacy ocean plastics.

4.15.T-02 NIST’s Efforts Toward Developing Micro- and Nanoplastic Research Grade Test Materials That Mimic Real-World Environments

Tae Joon Cho[1], John Pettibone[1], Abigail Lindstrom[1], Diana Ortiz-Montalvo[1], Danuta Liberda Matyja[1], Kurt Benkstein[1], Kristen Staffens[1] and Justin Gorham[1] (1)National Institute of Standards and Technology (NIST)

Development of ‘test materials’ for micro- and nanoplastic (MNP) particles is essential to advance the development of validated methods and protocols needed to provide more accurate chemical analysis including the identification and quantification. From a practical standpoint, relying on real-world MNP samples harvested from recycling facilities, landfills, or coastal environments presents a formidable logistical challenge, particularly in acquiring sufficient mass and achieving accurate characterization. Consequently, there has been a long-standing and escalating demand for “real-world-mimicking” MNP test materials that replicate the heterogeneity of environmental plastics—such as polydisperse size distributions, highly irregular shapes, and random surface morphologies—to elevate secondary physicochemical metrology.
To address this gap, top-down production via cryomilling has emerged as a viable strategy for transforming

bulk commercial polymers into irregularly shaped particles. This presentation outlines the development of an optimized protocol designed to generate a MNP, research-grade test material (< 10 μm) that mimic real-world environment from commercial polyethylene terephthalate (PET). Our group at National Institute of Standards and Technology systematically evaluated the reproducibility of this method by investigating critical parameters, including process induced variation in PET sources, milling duration, grinding ball dimensions, and subsequent dispersion and filtration techniques.
The resulting particles were comprehensively characterized using an advanced orthogonal analytical suite. Laser diffraction (LD) provided rapid screening of particle size distributions. Flow image microscopy (FIM) and particle tracking analysis (PTA) were deployed to quantify the micro-scale (> 1 μm) and nano-scale (< 1 μm) fractions, respectively. Furthermore, scanning electron microscopy (SEM) verified particle shape and surface topography, while optical photothermal infrared (O-PTIR) spectroscopy confirmed chemical composition and structural integrity at the sub-micron level. Finally, we discuss ongoing challenges in final product sampling for end-users. Because retaining a statistically meaningful nano-fraction is vital for authentic MNP research grade test materials, our current efforts focus on optimizing filtration yields and concentration methods to minimize the loss or aggregation of these ultra-fine particles.

Disclaimer/Disclosure: Identification of certain equipment, instruments, or materials in this presentation is not intended to imply recommendation or endorsement of any product or service by NIST, nor is it intended to imply that the materials or equipment identified are necessarily the best available for the purpose.

4.15.T-03 A Novel Workflow To Identify Both Polymers and Plastic Associated Chemicals in a Single Environmental Plastic Sample: A Case Study on Derelict Fishing Traps

Catherine Wardinski[1], Donna Bilkovic[1], Kirk Havens[1], Andrew Scheld[2], David Stanhope[1], Kory Angstadt[1], Noah Tait[1] and Meredith Seeley[1] (1)Virginia Institute of Marine Science, William & Mary, (2)Virginia Institute of Marine Science, William and Mary

Microplastics are far from a singular contaminant. They are chemically diverse, with over 100 polymer types and over 16,000 plastic associated chemicals (PACs) used in production. Established methodologies for analysis (e.g., Fourier transform infrared spectroscopy: FTIR) only provide information on polymer type, providing little distinction within polymer classes (e.g., polyamides or vinyls) or PAC identification. Detailed chemical characterization is extremely important for fate and toxicity evaluations, especially for high-abundance forms of plastic pollution. Abandoned, lost, and discarded fishing gear (ALDFG) is one such example. ALDFG pots and traps are a major source of plastics and microplastics to the environment, with 25 million lost globally across the seafloor each year. Yet, their chemical composition has not been studied. In conjunction with a large-scale, multi-country derelict trap removal and data collection program (National TRAP Program), we collated samples of traps for chemical characterization. Aliquots of each component across multiple replicates per fishery were collected for analysis via FTIR and sequential Thermal Desorption - and Pyrolysis - Gas Chromatography/Mass Spectrometry (TD & Py-GC/MS). The latter is unique because it allows for both non-targeted analysis of PACs and polymer identification, respectively, using the same sample with minimal preparation. Our results highlight the power of Py-GC/MS for fine-tuned polymer identification, compared to FTIR. We show that traps are complex, with multiple plastic components and variability in polymer type across replicates of a single component. The most common polymers were vinyls (in coated wire) as well as polyethylene and nylon hard-plastic pieces. Multiple groups of PACs were detected, including UV-

stabilizers, plasticizers, non-intentionally added substances, colorants, and lubricants, across different pieces. The PlastChem database was mined for each detected PAC providing information on the chemical use, hazard, and regulation. This research allows us to build a comprehensive picture of complex plastic components in environmentally recovered plastics from an understudied environmental sector, with minimal sample cost and preparation time. This provides a unique and valuable framework for simultaneous polymer and additive analysis, which is applicable across a wide variety of samples, including the analysis of microplastics from environmental samples.

4.15.T-04 Advancing Mass-Based Quantification of Micro- and Nanoplastics in Drinking Water Through Comprehensive Pyrolysis-Gas Chromatography-Mass Spectrometry Method Validation

Clementine Troncy[1] and Sebastien Sauve[1] (1)University of Montreal (UdeM)

Microplastics and nanoplastics have emerged as contaminants of concern due to their widespread occurrence in environmental and drinking water systems. While microscopy-based techniques provide valuable information on particle size and morphology, they remain limited for the detection and quantification of smaller particles and do not directly provide mass concentrations. Pyrolysis-gas chromatography-mass spectrometry (Py-GC/MS) offers an alternative approach through polymer-specific mass quantification; however, method validation remains insufficiently documented, even for simple matrices such as drinking water.

The objective of this study was to develop and validate a Py-GC/MS method for the quantification of micro- and nanoplastics in drinking water and bottled water. The method targets 13 polymers commonly reported in environmental samples, including polyethylene, polypropylene, polystyrene, polyethylene terephthalate, polyvinyl chloride, polycarbonate, polymethyl methacrylate, nylon-6 and nylon-6,6, polytetrafluoroethylene, polyacrylonitrile, acrylonitrile-butadiene-styrene, and styrene-butadiene rubber. Water samples were filtered using 0.2 µm glass fiber filters, allowing the inclusion of a fraction of nanoplastics that is often excluded from conventional microplastic analyses. Quantification was performed using polymer-specific pyrolysis products and high-resolution (120,000) mass spectrometric detection.

Method validation included the assessment of linearity, limits of detection, accuracy, repeatability, inter-day and inter-person precision, recovery, and various matrix effects. Validation results demonstrated low-µg/L detection limits, acceptable repeatability for most polymers, and satisfactory recoveries across a broad concentration range. Matrix effects were generally limited but highlighted the importance of marker selection and background contamination control when analyzing low-level environmental samples.

The validated method is currently being applied to drinking water and bottled water samples collected in Quebec, Canada, from a range of packaging materials and origins. Preliminary environmental results indicate measurable concentrations of several polymer types, demonstrating the applicability of the approach to real-world samples. This work contributes to the ongoing harmonization of mass-based microplastic analysis and provides a framework for the robust quantification of micro- and nanoplastics in drinking water matrices.

4.15.T-05 Successes and Lessons Learned From a Regional-Scale Microplastic Monitoring

Campaign

Leah Thornton Hampton[1] and Alvine Mehinto[1] (1)Southern California Coastal Water Research Project

The Bight Regional Monitoring Program has tracked the ecological health of Southern California's coastal waters every five years since 1994. The program has historically focused on sediment quality but also provides opportunities to ask novel questions and apply new methods. The 2023 Bight program sought to assess microplastic contamination in sediment and mussels by applying newly harmonized methods for sample collection, processing and analysis. More than 15 collaborating institutions were convened to identify key questions and devise and implement a pilot microplastics monitoring study. Laboratories underwent an intercalibration exercise using spiked samples to ensure comparability of results prior to analyzing field-collected sediment and tissue samples. Sediment samples were collected from estuaries (n = 21 sites), embayments (n = 30 sites), and the inner shelf (n = 30 sites). Mussels were collected at 24 unique coastal sites. A data portal was created to receive and manage microplastics monitoring data, including QA/QC data. For each sample, total suspected microplastic count ≥ 125 µm was determined, and particles were also characterized by nominal size fraction, color, and morphology. A subsample of up to 75 particles was measured to determine length and width and analyzed via spectroscopy to determine material type. More than 93% of samples met the predetermined data quality objectives for background contamination and surrogate particle recovery. Microplastic concentrations and characteristics were reflective of comparable habitats around the world. The results will be used to identify potential contamination hotspots and priority matrices and habitats for future efforts. Successes and lessons learned will be highlighted to inform upcoming microplastic monitoring campaigns as California expands microplastic monitoring as part of the Statewide Microplastics Strategy.

4.15.T-06 From Environmental Matrices to Aquatic Organisms: Optical Photothermal IR-Raman Microscopy for the Detection and Characterization of Microplastics and Nanoplastics

Pedro Mena-Giraldo[1], Shamsunnahar Suchana[1], Sangeeta Vidyarthi[2], Philip Jonsen[3], Ana C.Quevedo[1], Arav Saherwala[3] and Nathalie Tufenkji[4] (1)Postdoctoral Researcher, (2)Undergraduate Student, (3)PhD Student, (4)Professor

Environmental weathering of plastics can lead to the formation and release of microplastics and nanoplastics, while simultaneously inducing chemical modifications on their surfaces, such as oxidation. These physicochemical transformations can alter particle dispersion, interfacial interactions, and adsorption behavior in aquatic systems, resulting in increasingly complex environmental fate and transport processes. In addition, microplastics and nanoplastics represent an emerging environmental concern due to their potential toxicity, their role as vectors for co-contaminants, and their bioavailability and bioaccumulation across aquatic food webs. As interest in understanding the occurrence and impacts of these particles continues to grow, there is an increasing need to improve analytical methodologies capable of detecting, identifying, and characterizing microplastics and nanoplastics in terms of morphology and chemical composition across complex environmental and biological matrices. For example, challenges remain in understanding how environmental weathering conditions induce surface oxidation in plastics, in achieving accurate IR-based identification of individual microplastics, and detecting smaller particle sizes within complex matrices such as organism tissue. Our group is developing experimental and analytical approaches to study environmentally weathered microplastics and nanoplastics, and to optimize their detection in aquatic organisms using advanced spectroscopic techniques. In this presentation, I

will discuss the application of optical photothermal IR-Raman microspectroscopy (O-PTIR) for the characterization of the surface oxidation in UV-weathered paint flakes before and after microplastic and nanoplastic formation, supporting studies on environmental toxicity. I will also present examples involving the identification of fragment, film and fiber microplastics extracted from bivalves, and the detection of tire-derived nanoplastics associated with Daphnia magna tissue. Overall, this presentation will demonstrate how systematic analytical and methodological considerations for the combined use of Raman and IR spectroscopy in O-PTIR can increase confidence in the detection, visualization, and characterization of microplastics and nanoplastics across different types, morphologies, and complex sample matrices.

Disclaimer/Disclosure: Health Canada, Fisheries and Oceans Canada, NSERC (Discovery Program and CREATE MIXCHEM), and the Canada Foundation for Innovation.

From Detection to Direction: Advancements and Best Practices for the Detection and Quantification of Micro- and Nanoplastics in Complex Media

4.15.P-Tu172 Identification of Plastic Particles in Whole Organisms Using Optical Photothermal IR Microscopy and Tissue Clearing

Arav Saherwala[1], Pedro Mena-Giraldo[1], Jun-Ray Macairan[2] and Nathalie Tufenkji[1] (1)McGill University, (2)Trent University

The mass use of plastic products has led to plastic waste affecting aquatic and terrestrial environments. In the environment, bulk plastic items can break down into microplastics and nanoplastics due to weathering conditions. There is concern that the smaller nanoplastic fraction may be more hazardous than microplastics due to its potential to cross biological membranes. However, there is limited knowledge on the occurrence, environmental loads, and fate of nanoplastics in the environment. Hence, to improve our understanding of the impact of nanoplastics, characterization methods to identify these small, plastic particles in complex natural matrices must be developed. This work focuses on the development of an advanced imaging technique for detecting nanoplastics and microplastics in environmental samples, such as whole organisms, using optical photothermal IR microspectroscopy (O-PTIR). By combining histology techniques and tissue clearing, the IR spectra of polymers within a whole organism are better resolved, thereby improving the identification of plastic particles. One advantage of using the O-PTIR, which can image particles in the sub-micron range, is that the plastic particles do not need to be labelled prior to internalization by organisms. The proposed methodology can aid ecotoxicology studies in better understanding the uptake of plastic particles and will also help shape future research on the impact of microplastic and nanoplastic pollution on freshwater systems.

Disclaimer/Disclosure: Health Canada, Fisheries and Oceans Canada, NSERC (Discovery Program, CREATE MIXCHEM, and CGS-D), Fonds de recherche du Québec – Nature et technologies (FRQNT), the Canada Foundation for Innovation, and McGill MEDA.

4.15.P-Tu173 Pursuing the Small Fraction: Assessing Microplastics and Nanoplastics Migrating From Food Contact Articles Into Food Simulants

Karla Parga Martinez[1], Dana Kadadou[1], Arav Saherwala[1], Georgina Kalogerakis[1], Elsa Baxter[1] and Nathalie Tufenkji[1] (1)McGill University

Spectroscopic and thermal techniques are widely accepted in microplastic research, although inherent size limitations of small microplastics (< 10 μm) and nanoplastics (< 1 μm) continue to represent a major analytical challenge. In particular, the sub-micron fraction remains largely understudied and challenged by surrounding nanoparticles often misidentified as nanoplastics. Optical photothermal infrared spectroscopy (O-PTIR) is an emerging technique with a limit of detection at ~500 nm but that still relies on adequate sample preparation and the implementation of strict quality assurance and quality control (QA/QC) protocols. These QA/QC protocols are well established for microplastics work but the smaller-sized fractions require even more strict measures to limit airborne contamination. Here, we present robust methodologies developed for the analysis of small microplastics and nanoplastics applied to particle migration from plastic food contact materials into food simulants. We obtain complete profiles of polymer identification, particle size, particle morphology and mass data via O-PTIR and pyrolysis gas chromatography mass spectrometry. We also present QA/QC protocols specifically developed for small microplastics and nanoplastics to ensure data reliability and comparability.

Disclaimer/Disclosure: This work has received funding from Health Canada, Natural Sciences and Engineering Research Council of Canada, Canada Research Chairs, the Canada Foundation for Innovation and FONCER MIXCHEM CRSNG.

4.15.P-Tu174 A Comprehensive Evaluation and Open-Access Library for Microplastics Analysis With Laser Direct Infrared (LDIR) Spectroscopy

Jacob Ukropec[1], Kaleea Korunka[1], Catherine Wardinski[2], Robert Hale[2] and Meredith Seeley[2] (1)College of William & Mary, (2)Virginia Institute of Marine Science

Analysis of microplastics in the environment is difficult due to the sheer abundance and diversity of plastic and natural polymer particles, the need for separation from complex media, and the extensive analysis time for polymer identification. Instrumental techniques such as Fourier Transform Infrared spectroscopy (FTIR), Raman spectroscopy, and Pyrolysis-Gas Chromatography/Mass Spectrometry (Py-GC/MS) have been used to identify and quantify microplastics in environmental samples. Data acquisition using these methods, although beneficial, are often time and labor consuming, and in some cases destructive. The Agilent 8700 Laser Direct Infrared (LDIR) Chemical Imaging System provides a highly efficient, non-destructive alternative. Similar to Raman and FTIR, the LDIR conducts polymer identification via spectral matching to a reference library. However, the LDIR is unique in that it only captures the fingerprint region during spectral acquisition, inadvertently excluding some stereotypical IR peaks. Libraries included by the manufacturer are predominantly sourced from open access libraries, collected via attenuated total reflectance (ATR)-FTIR, modified to fit LDIR spectral limits. This process does not incorporate influences that the system or unique acquisition mode ("transflectance") may have on spectral signatures. This study creates the first LDIR Open-Access Library of Plastics and Other Polymers (LOLIPOP). Over 60 plastic and natural polymer standards were analyzed in microplastic form. Spectral variance was evaluated by acquisition of 20 spectra for each standard, highlighting both the polymers' strengths and potential susceptibility to false identification. Similarly, confidence levels

were determined by analysis of known polymer mixes, as well as blinded spike tests. Test results were used to highlight strengths and limitations of the instrument for environmental sample analysis. Preliminary results suggest that LDIR is unsuitable for analysis of tire crumb or rubber, as it is prone to type 1 error during analysis of other polymers. In addition, LDIR is limited in its ability to differentiate acrylonitrile butadiene styrene and polystyrene. The outcome of this study will provide an open access resource (LOLIPOP) and a refined evaluation of the LDIR's capabilities, contributing to more confident and accurate results.

4.15.P-Tu175 A Practical Comparison of Emerging Methods for the Analysis of Microplastics: Laser Direct Infrared Spectroscopy (LDIR) and Pyrolysis - Gas Chromatography/Mass Spectrometry (Py-GC/MS)

Robyn Dudrick[1] and Meredith Seeley[1] (1)Virginia Institute of Marine Science

Microplastics (MP; <5 mm) are ubiquitous environmental contaminants that increase in prevalence as particle size decreases. However, decreasing particle size leads to greater challenges in identification and quantification of MP, especially in environmental samples with complex matrices. Laser Direct Infrared spectroscopy (LDIR) and Pyrolysis-Gas Chromatography/Mass Spectrometry (Py-GC/MS) are two increasingly utilized techniques for the analysis of MP in environmental matrices. Despite targeting similar sample types and measurands (i.e., polymer type and concentration), the analytical windows, strengths, and limitations of LDIR and Py-GC/MS have yet to be directly compared. This study addresses this knowledge gap by comparing spiked controls and environmental samples, processed with identical methodologies, and analyzed with LDIR and Py-GC/MS. Spiked samples included ten target polymers (polyethylene, polypropylene, polycarbonate, polyethylene terephthalate, polystyrene, polymethyl methacrylate, polyamide-6, polyamide-6,6, polyvinyl chloride, and styrene butadiene rubber) of two common morphologies (fiber, fragment). Spike plastics were added, isolated, and extracted from three matrices (n = 6 sediment, n = 6 water, n = 9 air) along with processing blanks (n = 2). Samples were filtered (25 μm pore size), density separated (1.5 g/cm3), and digested (H2O2) prior to sequential analysis using LDIR followed by Py-GC/MS. A subset of samples was analyzed solely with Py-GC/MS to determine loss from transfer between LDIR and Py-GC/MS. Environmental samples (n = 9 sediment, n = 9 water, n = 3 field blank, n = 2 processing blanks) underwent identical isolation and extraction procedures as spiked controls, prior to sequential analysis via LDIR and Py-GC/MS. Polymer recovery, identification, and quantification will be compared between LDIR and Py-GC/MS. Results will clarify limitations in polymer identification and quantification, highlighting strengths and blindspots of each approach (e.g., morphological characterization, rubber identification). This study furthers our knowledge of MP types that may be vulnerable to under- or over-reporting using either instrument, while also evaluating the feasibility and utility of sequential analysis for a more wholistic assessment of MP in complex samples.

4.15.P-Tu176 Beyond the Particle: In-Depth Chemical Characterization of Diverse Paint Particles Toward Improved Environmental Detection

Meredith Seeley[1], Zoie Diana[2] and Bonnie Hamilton[3] (1)Virginia Institute of Marine Science, (2)University of Toronto, (3)University of Ottawa

Paint particles are estimated to be one of the most abundant forms of microplastic pollution in the environment, yet very few studies have investigated their abundance or distribution. This is partially attributable to challenges inherent with sample preparation methodologies. Paint flakes behave differently than other microplastics during

digestion and density separation, making them prone to loss during sample preparation. In addition, their analysis via spectroscopy (a common approach for microplastic analysis) has been limited by a paucity of reference spectra for library matching. Recently, the Paint Library of Plastic Particles (PLoPP) was created to improve spectroscopic identification of paint particles, increasing the likelihood for paint to be correctly identified in environmental studies. Spectroscopy, however, can only provide limited insight into the paint type or constituent chemicals. This study explores the analysis of paint with Evolved Gas Analysis (EGA-GC/MS) and sequential thermal desorption- and pyrolysis-gas chromatography/mass spectrometry (TD- and Py-GC/MS). Twenty-one paint types were analyzed, evenly sampled across seven commercial sectors: consumer, industrial, architectural, road, marine, automotive and wood paints. Despite paints being structured with a polymeric base, EGA-GC/MS revealed that paint particles thermal extraction and pyrolysis temperatures vary greatly from thermoset and thermoplastic polymers. Many paint types had extraction temperatures below 400˚C, contrary to the typical 450˚C required for polymer pyrolysis of other plastics. In addition, the signature of non-polymer constituents was evident below 250˚C, where many additive components evolved from the dry paint samples. TD-GC/MS positively identified many of these constituents as plastic associated chemicals of concern, including a variety of phthalate and flame retardant compounds across almost all sectors. Finally, Py-GC/MS was used to identify candidate polymeric markers for the distinction between alkyd, acrylic, urethane, epoxy and vinyl-based paints. This study provides novel insight into the environmental consequences of paint, particularly regarding their constituent chemicals, which is an under-appreciated but critical aspect of their physical fate and toxicity. Further, this provides practical advice on the analysis and differentiation of paint particles in the environment using Py-GC/MS.

4.15.P-Tu177 Comparison of Laser Direct Infrared (LDIR) Spectral Libraries for Accurate Identification of Tire Wear Particles in Stormwater

Stefanie Whitmire[1], Barbara Beckingham[2], Kayli Paterson[3] and Diana Lin[3] (1)Clemson University, (2)College of Charleston, (3)San Francisco Estuary Institute

Tire wear particles (TWPs) are increasingly recognized as an important class of microplastic pollution, particularly in stormwater runoff where they are efficiently mobilized from road surfaces. Accurate identification of TWPs remains challenging due to their complex composite materials that are chemically variable, environmental weathering, and poorly represented in spectral reference libraries. This study presents the development and validation of a tire wear particle-specific Laser Direct Infrared (LDIR) spectral library and evaluates how spectral match quality thresholds influence TWP identification and quantification in stormwater samples collected during a monitoring campaign in two urban streams in San Francisco. Reference spectra will be generated from tire tread materials and laboratory-produced tire wear particles and incorporated into a custom spectral library. Identical stormwater particle datasets will be processed using multiple spectral libraries, including supplied microplastic libraries and created libraries containing tire rubber reference spectra. Library performance will be assessed by comparing particle identification rates, polymer assignments, spectral match scores, and classification consistency. Agreement among libraries will be quantified using percent agreement and Cohen's kappa statistics. Differences in library performance will be used to evaluate the influence of spectral database composition on TWP identification. The results are expected to reveal variability in TWP classification among spectral libraries and demonstrate the importance of library selection in LDIR-based microplastic analysis. We expect the inclusion of a TWP-specific spectral library will improve classification confidence and reduce ambiguity in TWP particle assignments. This work contributes to the development of

standardized analytical approaches and improved reliability in the environmental monitoring of tire wear particle pollution.

4.15.P-Tu178 Simultaneous Tire Wear and Microplastic Enumeration in a Highly Urbanized Waterbody - Virginia's Elizabeth River

Kaleea Korunka[1], Meredith Seeley[2] and Catherine Wardinski[2] (1)College of William & Mary, (2)Virginia Institute of Marine Science

The Elizabeth River - a major tributary of the Chesapeake Bay in Norfolk, Virginia - has played a central role in regional ecological and industrial history, with notable industrial contamination sites. While the river has been extensively monitored for traditional water quality indicators through a massive, state-supported restoration effort (the Elizabeth River Project), microplastics and tire wear particles remain largely uncharacterized. This study aims to establish microplastic and tire wear particle abundance across several tributaries in the highly urbanized watershed of the northern Elizabeth River. Sites selected represent industrial, military, residential, and mixed-use water inputs, with a distribution of water quality parameters from regular monitoring. Samples were collected with a peristaltic pump equipped with an inline filtration apparatus. At each site, 20L of river water were filtered onto 300 µm and 50 µm metal filters at the surface (1ft below the surface) and bottom (1ft above sediment) for each location, once a month on four consecutive visits. Samples underwent hydrogen peroxide digestion to remove organic matter interference. To quantify both microplastics and tire wear particles, samples were analyzed with pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS). This approach to simultaneously quantify the mass of tire wear and targeted plastic polymers (including polyethylene, polypropylene, polystyrene, polyethylene terephthalate, poly(methyl methacrylate), polycarbonate and nylon) is unique among environmental studies, which typically focus on spectroscopic-based polymer identification and particle enumeration. To better compare to existing studies, a sampling effort doubled collections to additionally analyze via Laster Direct Infrared (LDIR) spectroscopy, providing particle enumeration, characterization and polymer identification for all target polymers except tire wear. Our results will be presented and integrated with historical water quality data from the Elizabeth River Project to evaluate potential relationships between microplastics and established indicators of river health. Findings from this study will provide the first targeted assessment of microplastics as emerging contaminants in the Elizabeth River, establishing a baseline for future monitoring, management strategies, and community-focused restoration efforts.

4.15.P-Tu180 Microplastics in Rainwater of Miguel Hidalgo Borough, Mexico City, During the Rainy Season 2025

Patricia Ramírez-Romero[1], Joshua Gutiérrez-Pacheco[1] and Libnny Citlalli Miranda-López[1] (1)Universidad Autónoma Metropolitana-Iztapalapa

Microplastics (MPs) have emerged as contaminants of global environmental concern. Recent studies have shown that these particles are also actively participate in atmospheric processes, enabling long-range transport and subsequent deposition through precipitation. Consequently, rainwater represents a potential exposure pathway for both ecosystems and human populations. In water-stressed regions such as Mexico City (CDMX), harvested rainwater is commonly used as a supplementary source for domestic purposes and even for human consumption. Therefore, the objective of this study was to evaluate and characterize the presence of MPs in rainwater during the 2025 rainy season in Miguel Hidalgo Borough, CDMX. A total of 14 rainwater samples

were collected between May and June 2025. For each sampling, precipitation volume and collected sample volume were recorded to estimate the atmospheric deposition rate of MPs. Samples were filtered using filter paper, and MPs were quantified and morphologically characterized using a digital microscope and HiView software. In addition, gas chromatography–mass spectrometry (GC–MS) was employed to identify the main monomers associated with the detected particles. MPs were detected in all samples, with an average deposition rate of 251 $MP \cdot day^{-1} \cdot m^{-2}$, comparable to values reported in Asian countries and higher than those observed in several European regions. Fibers (85.4%) and fragments (6.5%) were the dominant particle types. Styrene, dimethyl terephthalate, 1-undecene, and methyl methacrylate were identified, suggesting multiple anthropogenic sources. These findings demonstrate the widespread occurrence of MPs in rainwater from CDMX and highlight their potential risk to populations that rely on this resource under water-stress conditions.

4.15.P-Tu181 Isotope-Resolved Characterization of Polyethylene Using Pyrolysis Gas Chromatography Isotope Ratio Mass Spectrometry

Sakshi Khatri[1], Karlynne Dominato[1], Meagan Beaton[1] and Scott Mundle[1] (1)University of Windsor

Polyethylene (PE) is one of the most common polymers in environmental microplastic pollution, but particles identified as PE may still differ in source material, recycling history, additive-associated carbon pools, and environmental exposure. Molecular pyrolysis methods can describe PE degradation products, while pyrolysis-gas chromatography-isotope ratio mass spectrometry (Py-GC-IRMS) can additionally measure stable carbon isotope values of individual pyrolysis compounds. This study evaluated whether Py-GC-IRMS can distinguish isotopic variability among pristine low-density PE (LDPE), high-density PE (HDPE), recycled PE, and environmental PE materials using single-shot (SS) and double-shot (DS) analytical modes. SS analysis was used to compare polymer-derived homologous triplet patterns, including α,ω-dienes, α-alkenes, and n-alkanes. DS analysis separated thermally desorbable compounds from subsequent polymer pyrolysis products, allowing $\delta^{13}C$ values to be compared among compound families, sample types, and analytical modes. SS analysis produced consistent PE triplet patterns across most samples, supporting reproducible formation of polymer-derived pyrolysis products. Pristine LDPE and HDPE had diene and alkene $\delta^{13}C$ values of approximately −31 to −32‰, while recycled PE was more depleted, near −35‰, and showed altered peak-amplitude relationships. During thermal desorption, two reproducible peaks were observed, with $\delta^{13}C$ values differing by approximately 7‰, suggesting the presence of isotopically distinct thermally labile carbon pools. Comparison of SS and DS results showed that isotope responses differed among PE sources. Pristine PE remained relatively stable between modes, while recycled and environmental PE showed larger shifts after thermal desorption. Recycled PE became relatively ^{13}C-enriched during DS pyrolysis, whereas environmental PE showed more depleted $\delta^{13}C$ values, particularly in diene and alkene fractions. Overall, Py-GC-IRMS separated and measured isotope differences in polymer-derived and thermally desorbable carbon pools within PE. These findings support its use as a complementary approach for studying recycling-related variability, environmental alteration, and future microplastic source-attribution applications.

4.15.P-Tu182 Assessing Mass-Based Fates of Microplastics Throughout the Waste Water Treatment Process Using a Novel TD-GC-MS Methodology

Lihui An[1], Yang Zhang[2], Bing Zhang[3], Sydney Grinstead[4], Mike Chang[5], Hannah Calder[6] and Chris Llewellyn[6] (1)State Key Laboratory of Environmental Criteria and Risk Assessment, Chinese Research Academy of

Environmental Sciences, Beijing 100012, (2)Key Laboratory of Water and Air Pollution Control of Guangdong Province, South China Institute of Environmental Sciences, MEE, Guangzhou 510655, (3)Markes International, Shanghai 201109, (4)Markes International, Inc., Sacramento, California 95670, (5)Agilent Technologies, Inc., (6)Markes International Ltd

Sewage treatment plants (STPs) play a vital role in removing microplastics from wastewater but are also significant sources of microplastic pollution in the environment. Since STPs are not specifically designed for microplastic removal, understanding the mass-based fate of these particles during treatment is crucial for improving removal efficiency.

In this study, a thermal desorption–gas chromatography–mass spectrometry (TD–GC/MS) method was developed to quantify five common microplastics—polyethylene (PE), polypropylene (PP), polystyrene (PS), polyvinyl chloride (PVC), and polyethylene glycol terephthalate (PET)—within the size range of 0.22 μm to 5.00 mm. This approach was applied to assess microplastic fate throughout the entire STP treatment process. Unlike pyrolysis (Py)-GC/MS analysis the thermal desorption approach utilises an offline pyrolysis step which enables a large sample size; resulting in high levels of reproducibility between samples. The offline pyrolysis step also means that the pyrolyzate is not transferred to the GC column increasing robustness and time needed between system maintenance.

In this presentation we will detail how the mass-based quantitation used was a considerable improvement on estimations based on particle volume. The polymer concentrations for four size ranges was analysed at five stages during the waste water treatment process (influent prior to treatment, primary sedimentation tank, aerated grit chamber, secondary sedimentation tank and final effluent). The results compare the polymer abundance for the five polymer types and whether particle size impacts the efficiency of removal.

4.15.P-Tu183 Identification and Quantification of Microplastics (MPs) and Nanoplastics (NPs) Using Elemental Ratios As Markers

Chloé Desjardins[1] and Kevin Wilkinson[1] (1)University of Montreal (UdeM)

Plastic degradation releases microplastics and nanoplastics that could have an impact on human and environmental health. However, the analysis of microplastics (MPs) and nanoplastics (NPs) in complex matrices is challenging due to their small size and the omnipresence of natural organic matter. The objective of the project is to identify and quantify MPs and NPs in complex matrices based on their ratios of inorganic elements by spICP-ToF-MS (single particle inductively coupled plasma time-of-flight mass spectrometry). It is based on the hypothesis that the ratios of inorganic elements integrated into the matrix of single particles would be unique for different plastics and would differ from natural particles. The use of inorganic tracers is promising since it bypasses some of the limitations of current analytical techniques for detecting MPs and NPs. It is not size limited by optical diffraction like FTIR, Raman or microscopy and it allows analysis, without the interference of organic compounds which can be problematic in Pyr-GC-MS or techniques relying on the use of fluorophores or chromophores. The use of inorganic tracers has been previously reported with the use of synthetic plastics doped in complex matrices. The proposed method could give a better understanding of the behavior of MPs and NPs in complex systems by allowing the analysis of environmental MPs and NPs. Different plastic items have been digested to survey their elemental composition by ICP-MS in order to both identify the presence of marker elements and assess potential elemental ratios. Because the efficiency of ratios

depends on their spatial distribution in plastics, laser ablation-ICP-ToF-MS has been used to study the elemental distribution throughout the plastics. Preliminary results seem to indicate that ternary ratios of elements may be the most interesting for the identification and quantification of MPs and NPs. For example, the Ba:Fe:Ti ratio and Al:Ti:Sn have been identified as potential tracer ratios for a reusable food storage bag. Cryomilled microplastics and nanoplastics will be analysed by spICP-ToF-MS and quantified by their identified ratios and the suitability of the proposed method will be assessed by comparing it to other detection methods such as Raman, O-PTIR and Pyr-GC-MS.

4.15.P-Tu184 Detection of Microplastics in Aquatic Environments Using Flow Imaging Microscopy

Cléo Pereira[1], Anabelle Baya[2], Steeve Roberge[2] and Sébastien Sauvé[1] (1)University of Montreal, (2)Centre d'expertise en analyse environnementale du Québec

The intensive use of plastics over recent decades has led to their widespread presence across all ecosystems, making microplastic pollution a major environmental and health concern. In Quebec, freshwater systems are ubiquitous, including millions of lakes, rivers, and the St. Lawrence River. These aquatic environments are increasingly affected by microplastic contamination, driven by human activities and the hydrological dynamics of fluvial and estuarine systems. To better assess the risks associated with these emerging contaminants, it is essential to isolate, detect and characterize microplastic particles (MPs). However, current methods remain labor-intensive, time-consuming and costly.

This project aims to develop a method for the rapid analysis of microplastics in natural samples from aquatic environments, using flow imaging microscopy (FlowCam®). This technology combines imaging and fluorescence-based detection to enable the automated visualization of microplastic particles. The method targets six major polymers: polyethylene (PE), polypropylene (PP), polystyrene (PS), polyamide (PA), polyethylene terephthalate (PET) and polyvinyl chloride (PVC), in the size range of 20–1000 µm. Method development includes optimization of sample processing steps, including organic matter digestion and density separation for particle isolation, as well as their staining for fluorescence detection. The optimization of FlowCam® operating conditions is also a key step to improve particle detection and physical or size characterization efficiency. The method will be evaluated in terms of recovery efficiency and reproducibility across different water matrices, including tap water and natural waters.

Preliminary results demonstrate the potential of flow imaging microscopy as a rapid, robust and high-throughput approach for the detection of MPs. Beyond analytical performance, the method is suitable for routine monitoring and could complement existing microplastic monitoring programs by providing a faster diagnostic tool for assessing contamination levels. Ultimately, its implementation could contribute to large-scale monitoring strategies for a better understanding of microplastic pollution in Quebec's aquatic ecosystems.

Disclaimer/Disclosure: This project is funded by le Fonds bleu as part of the National Water Plan of the Québec Water Strategy, which implements concrete measures to protect, use and manage water and aquatic environments in a responsible, integrated and sustainable manner.

4.15.P-Tu185 A Curcumin-Based Fluorescent Microfluidic Platform for Sensitive Detection of Submicron Polyethylene Microplastics in Wastewater Effluents

Juviya Mathew[1], Ratul Kumar Das[1], Pouya Rezai[2] and Satinder Kaur Brar[1] (1)Department of Civil Engineering, Lassonde School of Engineering, York University, Toronto, Canada, (2)Department of Mechanical Engineering, Lassonde School of Engineering, York University, Toronto, Canada

Accurate detection of submicron microplastics (MPs) in wastewater (WW) remains a critical analytical challenge due to limitations in sensitivity and the environmental drawbacks of conventional dyes such as Nile Red (NR). This study introduces a novel, environmentally benign approach combining curcumin-based fluorescent labeling with microfluidic detection for the analysis of polyethylene (PE) MPs in WW effluents. Curcumin, a plant-derived fluorophore, was evaluated as a sustainable alternative to NR, offering reduced dye leaching and lower risk of analytical artifacts. PE MPs ranging from 200 nm to 9.9 μm were successfully stained, exhibiting stable green fluorescence across the size spectrum. Methanol-assisted destaining indicated reversible binding, suggesting predominantly non-covalent interactions, while Fourier-transform infrared (FTIR) spectroscopy confirmed no detectable alteration of polymer chemistry, ensuring analytical integrity. The microfluidic platform integrates electrophoretic transport with electrical resistance-based detection, enabling the identification of PE MPs in wastewater final effluent following minimal pretreatment using ultrasonication. The system demonstrated reliable capture and detection of PE MPs (~<500 nm), surpassing the lower size sensitivity limits of conventional analytical techniques (>1 μm). The signal response from resistance measurements indicates the potential for quantitative analysis, although further calibration is required to establish detection limits and reproducibility metrics. Compared to NR, curcumin reduces the risk of secondary contamination and dye-induced bias, supporting more accurate exposure assessments. This approach provides a rapid, and scalable analytical framework for MP monitoring. Overall, the integration of green fluorophores with microfluidic sensing represents a significant advancement in sustainable analytical chemistry, improving detection capabilities for emerging contaminants and strengthening environmental monitoring strategies relevant to WW systems.

4.15.P-Tu186 Construction of a Variability-Aware Raman Training Dataset for Microplastics and Evaluation of Recovery and Detection Applicability in Lake-Water-Spiked Samples

Ye Jee Jeon[1], Jun Hui Jeon[1] and Sung Ik Yang[1] (1)Kyung Hee University

Raman spectroscopy is widely used for the rapid and reliable identification of microplastics; however, approaches based on a single reference spectrum often fail to provide sufficient discrimination performance for real environmental samples. Even within the same polymer class, the relative intensities of characteristic bands, background fluorescence, and overall spectral profiles can vary substantially depending on particle size, surface oxidation state, material composition, and weathering or pretreatment history. Therefore, a model applicable to real environmental samples requires a robust training dataset that explicitly captures such spectral variability.

In this study, we constructed a Raman training and validation dataset for four representative microplastics—polyethylene (PE), polypropylene (PP), polystyrene (PS), and polyethylene terephthalate (PET). Rather than relying on a single standard particle for each polymer, we included samples derived from a range of commercial products so that the dataset would encompass spectral dispersion arising from differences in size, oxidation state, and material characteristics. Using this dataset, we trained and compared three classifiers—support vector

machine (SVM), random forest (RF), and convolutional neural network (CNN)—to evaluate the discrimination performance of the variability-aware training approach.

To assess real-world applicability, lake-water samples were spiked with the four polymers individually and as mixtures, followed by pretreatment, filtration, and Raman measurement. Recovery was evaluated as the ratio of detected to spiked particles, and the effects of matrix background signals and particle loss on detection performance were analyzed. The four microplastics were stably distinguished based on their characteristic Raman bands, and all three classifiers showed high validation performance. The variability-aware training dataset provided improved discrimination relative to a single-representative-spectrum approach and maintained reliable classification performance for the lake-water-spiked samples. These findings suggest that incorporating product-derived spectral variability into Raman training datasets can enhance the practical applicability of microplastic detection and identification in environmentally relevant matrices.

4.15.P-Tu187 Microplastic Ingestion and Depuration in Freshwater Organisms: Implications for Ecological Risk Assessment and Regulatory Frameworks

Naima Hamid[1], Andrew Barrick[1], Tyler Wojichowski[2], Stephen Duke[1] and Tham Hoang[1] (1)School of Fisheries, Aquaculture, and Aquatic Sciences, College of Agriculture, Auburn University, Auburn, AL, United States., (2)School of Fisheries, Aquaculture, and Aquatic Sciences, College of Agriculture, Auburn University, Auburn, AL, United States

Microplastics (MPs) are increasingly detected in freshwater ecosystems; however, their uptake and depuration kinetics in aquatic organisms remain insufficiently understood, particularly across species with different feeding behaviors and ecological niches. This study investigated the ingestion and depuration of environmentally relevant polystyrene microplastics (5 µm, 80 µm, 120 µm, and 3 mm red cup fragments) in four freshwater species (Physa acuta, Daphnia magna, Micropterus salmoides (largemouth bass), and Ictalurus punctatus (catfish larvae). Physa acuta and D. magna were exposed to MPs for 24 h, whereas largemouth bass and catfish larvae were tested for 96 h to characterize uptake and depuration kinetics. No mortality was observed in any species throughout the exposure period. Microplastic ingestion peaked at 24 h in D. magna (mean: 14 MPs/organism), largemouth bass (mean: 271 MPs/organism), and catfish larvae (mean: 379 MPs/organism), followed by a pronounced decline during the depuration phase between 28–48 h in D. magna and 72–96 h in fish species. In contrast, P. acuta exhibited rapid MP accumulation, with maximum uptake observed for 80 µm particles at 6 h (mean: 703 particles/organism). First-order toxicokinetic modeling revealed comparable uptake rate constants among fish species (largemouth bass: Ka = 0.42 MPs h^{-1}; catfish: Ka = 0.41 MPs h^{-1}). However, catfish demonstrated slower elimination kinetics (Kd = 0.03 MPs h^{-1}) and a longer time to reach 95% steady state (T95 = 93.0 h) relative to largemouth bass (Kd = 0.04 MPs h^{-1}; T95 = 68.7 h), indicating greater MP retention potential. Particle-size distribution analyses demonstrated selective ingestion of smaller MPs by P. acuta, D. magna, and catfish larvae, whereas largemouth bass showed less size selectivity and consumed relatively larger MPs. These findings demonstrate that MP uptake is strongly influenced by particle size, species-specific feeding behavior, and organismal size. Standardization of methodologies for environmentally representative MP design, along with long-term exposure studies, is required to assess toxicological impacts and improve ecological risk assessments and regulatory frameworks for aquatic freshwater ecosystems.

Keywords: Microplastics, ingestion; accumulation; depuration; toxicokinetics, risk assessment

4.15.P-Tu188 Discovery of Microplastic Abundance in the Feces of Shorebirds in Remote Areas of Alaska: Evidence of Widespread Ingestion by Birds

Andrew Barrick[1], Celia Slaughter[1], Tyler Wojichowski[1], Safeer Islam Hashmi[1], Shannon Brewer[2], James Magee[3], Kyle Cutting[3] and Tham Hoang[1] (1)Auburn University, (2)Auburn University; U.S. Geological Survey, (3)National Park Service

Microplastics are a pervasive contaminant found across the biosphere, including remote areas such as the Arctic, Antarctic, and deep ocean. How microplastics are transported and their effects on ecosystems with limited anthropogenic activity remain unclear. Birds can be useful bioindicators, as their high mobility and diverse trophic niches enable them to provide a holistic assessment of ecosystem health across large geographic areas. The aim of this study was to determine microplastic ingestion and accumulation in shorebirds in and around Yakutat, Alaska, a migration corridor of hemispheric importance for various shorebird species. Blood and fecal samples were collected from six bird species (Dunlin, Short- and Long-billed Dowitcher, Least Sandpiper, Wilson's Snipe, and Pectoral Sandpiper) in the Yakutat and Malaspina Forelands. Samples were digested, and microplastics were counted and characterized using Raman Spectroscopy. Surprisingly, microplastics in various colors were found in the majority of fecal samples, averaging 1.79 ± 2.02 particles/fecal sample (0.10 ± 0.28 particles/mg). The highest particle count per sample was 9 (0.03 particles/mg). Eighty-three percent of the microplastics were fibers, and 17% were fragments. The average size of fibers was 1,385 ± 2,076 μm, whereas the average size of the fragments was 463 ± 303 μm. Polyester was the most common. The study's results demonstrated that microplastic ingestion by birds is occurring and that microplastics may be transported to Alaska's relatively pristine environments through migration corridors. Follow-up studies aim to increase sample size, understand how microplastics may negatively affect birds, and explore the relationship between microplastics in shorebirds' prey and plastics present in the environment.

Keywords: microplastic pollution, microplastic ingestion, Alaska National Park

4.15.P-Tu189 Development of a Standardized Environmentally Relevant Micro- and Nanoplastics Library for Cytotoxicity Evaluation

Yuya Haga[1], Sota Manabe[2], Wakaba Idehara[2], Mii Hokaku[1], Phyo Bo Bo Aung[1], Yuto Motoyama[1], Ayaha Mori[2], Yudai Ikuno[1], Hirofumi Tsujino[1], Haruyasu Asahara[1], Ryotaro Tsutsumi[3], Kazuya Nagano[3], Kazuma Higashisaka[1] and Yasuo Tsutsumi[1] (1)Graduate School of Pharmaceutical Sciences, The University of Osaka, (2)School of Pharmaceutical Sciences, The University of Osaka, (3)School of Pharmaceutical Sciences, Wakayama Medical University

As highlighted in the Sustainable Development Goals (SDGs), increasing global concern has been focused on the potential adverse health impacts of plastic pollution, particularly microplastics (MPs, <5 mm) and nanoplastics (NPs, <1 μm). The detection of these particles in a variety of human tissues and biological specimens suggests that human exposure is both widespread and difficult to avoid. Environmental MPs/NPs (collectively termed MNPs) exhibit considerable heterogeneity in their physicochemical properties, including polymer composition, particle size, morphology, and surface characteristics. Nevertheless, the majority of current toxicological studies rely on simplified model particles, typically smooth and spherical, which do not adequately reflect environmentally relevant conditions.

To address this issue, we established a comprehensive MNPs library incorporating physicochemical features representative of environmentally occurring particles. In this study, the constructed MNPs library was

systematically characterized, compared with environmental samples, and evaluated for its cytotoxic potential. The library consisted of five commonly used plastic polymers: polyethylene (PE), polystyrene (PS), polypropylene (PP), polyvinyl chloride (PVC), and polyethylene terephthalate (PET). Particles were prepared with controlled variations in size (MPs and NPs), morphology (fragments, fibers, and spheres), and surface condition, including oxidative degradation induced by vacuum ultraviolet irradiation.
Comparative analyses with environmental MNP datasets demonstrated that the particles in the library closely reproduced the morphological and surface features observed in real environmental samples. In addition, cytotoxicity assessments revealed that surface-degraded MNPs induced measurable toxic responses in multiple cell lines, whereas non-degraded particles showed minimal cytotoxic effects. These results highlight the importance of incorporating environmentally relevant surface characteristics into safety and hazard evaluations. Future work will focus on expanding the MNPs library to include a wider range of materials and environmental conditions, as well as further investigating their biological effects. The MNPs library developed in this study will be made available to the research community upon request through collaborative arrangements (Contact: haga-y@phs.osaka-u.ac.jp).

Disclaimer/Disclosure: This work was supported by the Environment Research and Technology Development Fund (JPMEERF20241003) of the Environmental Restoration and Conservation Agency provided by Ministry of the Environment of Japan.

4.15.P-Tu190 Multimodal Assessment of Environmentally Relevant Nanoscale Plastic Reference Materials in Intestinal Organoid Models

Sadman Sakib[1], Maohui Chen[2], David Corriveau[2], Daniel Prezgot[2], Adrian Pegoraro[2] and Shan Zou[2]
(1)Metrology Research Centre, National Research Council (NRC) Canada, (2)Metrology Research Centre, National Research Council Canada

Environmental nanoscale plastics generated through weathering and fragmentation remain difficult to detect and evaluate within biological systems due to their heterogeneous physicochemical properties and low traceability in complex biological matrices. In addition, many toxicological studies continue to rely on pristine synthetic particles that inadequately represent environmentally processed plastics.
In this work, environmentally relevant nanoscale polypropylene reference materials (NPPP-1, Metrology, NRC Canada https://doi.org/10.4224/crm.2025.nppp-1) generated through ultrashort laser ablation were evaluated using advanced human intestinal models and complementary biological systems. These materials exhibit heterogeneous nanoscale morphologies, including disk-like shapes, and broad size distributions. They also exhibit oxidation-related surface chemistry typical of environmentally weathered plastics, while remaining compatible with biological exposure systems.
Exposure studies in human intestinal organoid and epithelial models demonstrated oxidative stress-associated responses, including increased reactive oxygen species generation, inflammatory signaling, lipid peroxidation, and activation of regulated cell death pathways, such as ferroptosis-associated responses. In organoid systems, exposure was additionally associated with activation of Wnt/β-catenin signaling pathways linked to epithelial stress responses and regenerative activity.
To address methodological challenges associated with nanoscale plastic detection in biological systems, multimodal imaging and spectroscopic workflows were applied to evaluate particle localization and biological association within exposed tissues and cellular systems. Complementary infrared imaging microscopy and

atomic force microscopy approaches demonstrated improved capability for assessing environmentally relevant plastics within complex biological matrices and advanced three-dimensional culture systems.
This work highlights the importance of integrating environmentally realistic nanoscale plastic reference materials with advanced human-relevant biological models and measurement-focused analytical approaches. These findings support improved assessment of nanoscale plastic exposure, mechanistic toxicology, and development of new approach methodologies relevant to environmental health and regulatory science.

4.15.P-Tu191 Polyethylene Microplastics in Aquatic Ecotoxicology: Systematic Review of Variability, Uncertainty, and Implications for Environmental Risk Assessment

Sungwoo Ahn[1] and Gregg Hancock[1] (1)The Dow Chemical Company

Polyethylene microplastics (PE MPs) have been used as model materials in laboratory ecotoxicology studies, however it is important to not overlook the importance and relevance of material selection. Data compiled in the ToMEx database for aquatic organisms, for example, has nearly 3,000 ecotoxicological endpoints reported for PE MP — second only to polystyrene, for which approximately 4,800 endpoints are available.

Despite the available data, biological responses to PE MPs remain highly variable across taxa, life stages, particle characteristics, and exposure scenarios, complicating hazard evaluation and ecological risk assessment. In many cases, reported endpoints are associated with substantial uncertainty arising from experimental design, particle selection, and exposure conditions. Literature screened using widely accepted microplastics research quality criteria was systematically reviewed to examine the physicochemical diversity of PE MPs, exposure designs applied in ecotoxicity studies, consistency and gaps in reported biological endpoints. Overall, this review highlights the need for standardized and environmentally relevant approaches in ecotoxicological testing to improve study methodologies and reduce uncertainty. Regulatory ecological risk assessment frameworks ultimately depend on reliable, reproducible, and defensible ecotoxicological data.

From Persistent Organic Pollutants to Plastics, Great Lakes to Arctic: Honoring Liisa Jantunen

4.16.T-01 Liisa Jantunen's Pioneering Research on Air-Water Gas Exchange

Terry F. Bidleman[1] and Liisa M. Jantunen[2] (1)Umeå University, (2)Environment & Climate Change Canada

In over 30 years of research, Dr. Liisa Jantunen made many first-time observations of air-water gas exchange of hydrophobic chemicals, especially in the Arctic and Laurentian Great Lakes. These contributions are noted today, as we celebrate her life and accomplishments.

Beginning as an undergraduate co-op student in the early 1990s, Liisa showed through fugacity modelling that the Bering-Chukchi seas were losing their accumulated burden of the pesticide alpha-hexachlorocyclohexane (α-HCH) by revolatilization, the first such study in Arctic waters. Her follow-up studies on several research expeditions employed the enantiomers of α-HCH to trace water-to-air volatilization. She provided the first demonstration that ice cover was an effective lid which dampened the exchange process. Ice breakup "popped the cork" on the Arctic Ocean champagne, allowing volatilization to take place again. It was satisfying to

confirm the fugacity predictions by actual measurements.

Estimates of gas exchange rely heavily on equilibrium air-water partition ratios, “Henry’s Law constants” (HLCs), which can be determined by painstaking methods in the laboratory. As a necessary component to her gas exchange studies, Liisa determined HLCs for OCPs, including HCHs, chlordanes, hexachlorobenzene (HCB), toxaphene. Her HLCs for naturally produced bromoanisoles are being used to predict their air-sea exchange in the northern Baltic (Bidleman
et al., Mar. Pollut. Bull. 2016).

Liisa extended her techniques to other organochlorine pesticides, culminating in a review, “20 Years of Air−Water Gas Exchange Observations for Pesticides in the Western Arctic Ocean” (Jantunen et al., Environ. Sci. Technol. 2015). She also showed how emissions of nonracemic OCPs from water and soil affect their enantiomeric signatures in Arctic and Great Lakes air.

Liisa’s contributions in gas exchange and HLCs have been cited by others >1400 times in >900 publications (WoS). Her work with enantiomer tracers was noted as examples in the book “Chiral Environmental Pollutants, 2nd ed. (Kallenborn et al., 2021). Truly, accomplishments worthy of popping the cork!

Disclaimer/Disclosure: Our Baltic research in collaboration with Liisa has been supported by the Swedish marine strategic research environment EcoChange (https://www.umu.se/en/ecochange/), Swedish Research Council Formas).

4.16.T-02 POPs to "POPs": Liisa Jantunen’s Contributions to Microplastics and Related Chemical Contaminants

Paul Helm[1] (1)School of the Environment, University of Toronto

From organochlorine pesticides (old POPs) to microplastics (persistent organic particulates?...new “POPs”??), Dr. Liisa Jantunen’s work and contributions are interwoven through research in our indoor environment, the urban environment to the Arctic. After early work on air-water exchange and long range transport of organochlorine pesticides in the Great Lakes and the Arctic, Dr. Jantunen added flame retardants (organophosphate esters; now “plastics additives”) and the indoor environment to her research portfolio. Most recently, Dr. Jantunen delved into microplastic pollution in broad environments and matrices, from dusts in the indoor environment to the snow in the Arctic, and including air, water, sediments and fish in environments and regions in between. Ideas, experiences, and sampling efforts provided by Dr. Jantunen demonstrated the widespread presence of microplastics and denim fibers across the arctic and in transects of declining abundance from the source regions of the Great Lakes to the more remote Arctic. She helped explore local source contributions of microplastics in the arctic, and contributed to the development of methods and approaches to assess levels of plastics in dusts and air in the indoor environment. She also stuck to her fate and transport process roots through collaborative efforts to understand drivers of microplastics particle atmospheric transport. One of Dr. Jantunen’s lasting contributions are the opportunities provided to students and colleagues through collaboration and funding support to gain field experience and to conduct studies in parts of the Canada that so few get to see and experience first hand. Her leadership has led to many well-rounded researchers and professionals working across sectors, around the world, paying it forward. Having a career that has paralleled

Dr. Jantunen's from the days of sharing lab and office space, it has been an honour to work with her and to now reflect on her scientific and mentoring legacy.

4.16.T-03 Principle Components Analysis Reveals the Drivers of Microplastic Pollution in the Thames River Watershed

Patricia Corcoran[1], Dinithi De Silva[1], Jiali Feng[1] and Liisa Jantunen[2] (1)University of Western Ontario, (2)ECCC

Plastic debris is widely dispersed across multiple depositional compartments, for example, in sediment, soil, water, air, and animals. The dispersal of microplastics and macroplastics can vary substantially depending on the: (i) nature and location of the source, (ii) composition, shape, and size of the plastic particle, (iii) proximity to point of entry into the environment, (iv) type and energy of the transport process, and (v) multiple characteristics of the depositional environment. Determining the main driver(s) of plastic pollution in a specific watershed is therefore highly complicated. Principal Components Analysis (PCA) is a tool that is often used for multivariate data analysis because it transforms a set of variables into a smaller number of uncorrelated principal components. By employing comparative PCA of microplastics and macroplastics in multiple stormwater ponds within the Thames River watershed of Ontario, Canada, we are able to prove that different factors drive pollution depending on debris size. Pond size and morphology, and local land use were the dominant drivers of macroplastic accumulation whereas particle type and land use were the key drivers for microplastics. Ongoing PCA of the datasets from other sampled compartments within the same watershed are uncovering the most significant controls on plastic debris types, deposition, and distribution. These compartments include air, surface water, surface sediment, river and creek bottom sediment, agricultural soil, and fish. Empirically revealing the drivers of both macroplastic and microplastic pollution throughout the Thames River watershed is crucial for developing reduction and mitigation strategies with the general public, government authorities, First Nations, and plastic industries.

4.16.T-04 Multi-Decadal Contaminant Trends in Polar Environments

Amila De Silva[1], Amy Sett[2], Gabrielle Myszkal[2], Cassandra Brinovcar[1], Jane Kirk[1], Johan Wiklund[3], Melissa Lafreniere[4] and Scott Lamoureux[4] (1)Environment and Climate Change Canada (ECCC), (2)Environment and Climate Change Canada, (3)University of Waterloo, (4)Queen's University

The Cape Bounty Arctic Watershed Observatory (CBAWO) is located at 74° 50′ N, 109° 30′ W on Melville Island, Nunavut, Canada. There are two well-studied adjacent lakes in CBAWO. East Lake and West Lake have similar lake areas (1.6 and 1.4 km2) and watershed areas (11.6 and 8 km2). These lakes are in a zone of continuous permafrost and have an active layer 50-70 cm deep. Extreme summer temperatures in 2007 resulted in a deep surface thaw leading to over a hundred active layer detachments. West Lake subsequently experienced subaqueous slumps (also known as multiple underwater mass movement events), visually obvious by an increase in turbidity. Previous research has shown impacts on fish body condition and contaminants such as mercury and organochlorines in fish and plankton. Sediment cores are a useful tool for evaluating the lake history. Earlier work using sediment cores in CBAWO were used to further understanding of hydroclimatic controls on sedimentation. In this research, we report contaminants in sediment cores from East and West Lake to test the hypothesis of increased contaminant inputs via climate change. A gravity corer was used to retrieve sediment cores in May 2024. Cores were sectioned in 1 cm intervals and freeze dried for dating by lead-210

analysis. Freeze dried sections were analyzed for contaminants to construct contaminant deposition trends in the two lakes.

Disclaimer/Disclosure: Funding - Environment and Climate Change Canada's Air Quality Research Program (AD, JK). Support from Natural Resources Canada's Polar Continental Shelf Program (JK, ML), Discovery Grant and Northern Supplements (both Natural Sciences and Engineering Research Council of Canada to ML).

From Persistent Organic Pollutants to Plastics, Great Lakes to Arctic: Honoring Liisa Jantunen

2.01.V-02 Microplastics in Arctic Moss and Lake Water Reflects a Local Source Component, Iqaluit, Nunavut

Kelly Evans[1], Patricia Corcoran[2], Liisa Jantunen[3] and Julian Aherne[4] (1)No Affiliation, (2)University of Western Ontario, (3)Environment and Climate Change Canada, (4)Trent University

Microplastics (MPs) are contaminants of emerging Arctic concern due to their adverse effects on individuals and ecosystems, yet lake water and shorelands on Baffin Island, Nunavut, remain understudied for microplastic contamination. To address this knowledge gap, we quantified microplastic pollution in moss, bulk and volume-reduced water, and lakeshore sediment collected from nine lakes east and upwind of Iqaluit, Nunavut, and ten lakes north and downwind of Iqaluit. Stair-step moss (Hylocomium splendens) was used as a proxy for atmospheric transport of MPs into the lake areas, which was predicted to be the dominant pathway for microplastics to the lakes, whereas water and sediment were sampled to understand the depositional fate of MPs. Our results show that average microplastic concentrations were greater in lake water and stair-step moss upwind of Iqaluit compared to their downwind counterparts. In addition, mean microplastic abundance decreased with increasing distance from the community, suggesting a local source input from the community. A positive correlation between the concentration of MPs in lake water and stair-step moss suggests that the lakes received atmospheric microplastics and supports the viability of using the latter as a proxy to better understand the transport of microplastics into terrestrial Arctic ecosystems. The results of our study indicate that, in addition to long-range transport of MPs to the Arctic, local inputs also contribute to the microplastic burden in northern remote Arctic regions.

4.16.V-01 Cruise Ships As Emerging Sources of Chemical Contaminants and Human Exposure in Polar Regions

Veronica van der Schyff[1], Lisa Melymuk[1], Rozarka Jilkova[1], Branislav Vrana[1], Marek Stiborek[1], Zdenek Simek[1], Petr Kukucka[1], Jiri Kohoutek[1], Ondrej Audy[1], Andrew Luke King[2] and Verena Meraldi[3] (1)Masaryk University, (2)NIVA, (3)HX Expeditions

Polar regions are experiencing rapid environmental change alongside increased human activity, including rising tourism. Recently, cruise traffic in polar regions has expanded substantially, driven by receding sea ice, improved ship technology, and growing demand for remote travel experiences. This growth introduces a new vector for anthropogenic chemicals to reach remote areas, adding to existing pressures of long-range transport. To address knowledge gaps related to cruise ship impacts on humans and the environment, we conducted air,

dust and wastewater sampling aboard three expedition cruise ships operating in Northern European, sub-Arctic and Arctic regions. Suspect screening of wastewater effluent from ships revealed a complex mixture of >160 organic contaminants, dominated by pharmaceuticals (43–59% of identified compounds), followed by industrial chemicals and natural products. Cardiovascular drugs and antibiotics were consistently detected across vessels, raising concerns about ecological impacts and the potential promotion of antimicrobial resistance in marine environments where degradation is slow. These results suggest cruise ship wastewater is an important but under-characterized local contaminant source in heavily cruised Arctic and sub-Arctic regions.
In parallel, we evaluated the indoor air and dust of cruise ships for plastic additives, and flame retardants presented a particularly unique case, aligning with the heavy use of flame retardants to meet strict flammability requirements on ships. Indoor dust from the sampled expedition cruise ships had high concentrations of organophosphate esters, notably tris(1-chloro-2-propyl) phosphate (TCIPP), which dominated chemical profiles and reached mg/g levels in dust. Spatial variability within ships reflected furnishing and material use. Exposure estimates indicated that crew members may experience elevated chronic exposure due to prolonged time spent onboard, and such occupational exposure considerations should be given greater attention.
Together, these findings demonstrate the potential for cruise ships to act both as point sources of contaminants to Arctic marine environments and as unique microenvironments for human chemical exposure. With the continued expansion of cruise ship and polar tourism, these local inputs are likely to increase in importance, underscoring the need for improved monitoring, as well as better characterization of complex chemical mixtures used in maritime transport.

From Persistent Organic Pollutants to Plastics, Great Lakes to Arctic: Honoring Liisa Jantunen

4.16.P-Tu100 Liisa Jantunen: An Overview From Current Use Pesticides to Organophosphate Esters

Miriam Diamond[1] (1)University of Toronto

Spanning over three decades, Liisa Jantunen made indelible contributions to understanding issues of environmental contamination and to the scientific and broader community. Liisa's major contributions were towards understanding the distribution and dynamics of Persistent Organic Pollutants (POPs), particularly in the Arctic, as explained by Terry Bidleman. Following from her early work on legacy POPs, she developed analytical methods for, and then with collaborators, characterized levels of current use pesticides (CUPs). In the Arctic, she contributed to showing the importance of precipitation, preceded by long-range transport, as the pathway of CUPs into the Arctic Ocean. With collaborators, Liisa used enantomeric fractions as clues to determine recent versus older sources of CUPs to air and water. For example, enantomeric fractions were used to identify the release to air of recently applied DDT as well as older DDT applied to soils in southern Mexico and chlordane from urban areas in Japan and the Pacific Northwestern US. Liisa also contributed to documenting concentrations of CUPs and legacy pesticides in indoor air from social housing in the Toronto area, showing that their longevity indoors, even 40 years after use restrictions, results in on-going exposure to residents. Finally, Liisa was early to analyze the properties and environmental distribution of organophosphate esters. This research was critical to understanding that organophosphate esters undergo long-range atmospheric transport to the Arctic where they can reach relatively high levels and pose a risk of exposure to wildlife.

From Tread to Watershed: How Tire Wear Particles and Chemicals Affect Aquatic and Terrestrial Ecosystems

4.17.T-01 Application of Laser Direct Infrared and Pyrolysis GC-MS To Quantify Tire Wear Particles in Urban Stormwater Runoff

Diana Lin[1], Kayli Paterson[1], Barbara Beckingham[2], Stefanie Whitmire[3], Elisabeth Rødland[4], Win Cowger[5] and Alicia Gilbreath[1] (1)San Francisco Estuary Institute, (2)College of Charleston, (3)Clemson University, (4)Norwegian Institute of Water Research, (5)Moore Institute for Plastic Pollution Research

Tire road wear particles (TRWPs) are a priority type of microplastics identified for stormwater monitoring, but there are not yet established methods for sampling and analysis of this challenging matrix and contaminant. The Regional Monitoring Program for Water Quality in San Francisco Bay (RMP) seeks to establish a robust stormwater monitoring framework to support stormwater information needs relating to a broad set of prioritized legacy and emerging contaminants. The goal of this study was to pilot stormwater sampling and laboratory analytical methods for quantifying TRWP and other microplastics in urban stormwater runoff and inform cost-effective approaches for future RMP stormwater monitoring.

We measured the vertical concentration profile of multiple particle classes in stormwater runoff at two urban channels in the San Francisco Bay region. TWPs were analyzed using both Laser Direct Infrared (LDIR) and pyrolysis gas chromatography–mass spectrometry (Py-GC-MS). Microplastics (without TRWPs) were analyzed using Fourier-Transform Infrared (FTIR) spectroscopy. More conventional particle profiling analyses, suspended solids concentration and turbidity, were also measured. The LDIR chemical imaging system was used to quantify TRWP >20 μm, for which particle counts were orders of magnitude more abundant than had previously been reported and compared to other types of microplastics. TRWP mass in urban stormwater runoff was estimated to be in the low mg/L range. In the well-mixed channels, we examined TWP concentrations as a function of time across the storm event's hydrograph and as a function of sample collection depth at each time step (grab samples). Greater variability was associated with time of sampling compared to the sampling depth, informing future efforts to develop more cost-effective sample collection approaches using remote samplers, which typically have a single-depth intake. Lessons learned from the field sampling and analytical approaches will inform a follow-up study to evaluate the levels of TWPs in more geographically distributed watershed locations in the San Francisco Bay region and beyond.

4.17.T-02 Identifying Chemical Fingerprints To Track Tire Wear Particle (TWP) Pollution in Urban Watersheds

Stephanie Eytcheson[1], Chloe Mellgren[2], Ian Mundy[2], Melissa Maurer-Jones[2] and Bridget Ulrich[1] (1)Natural Resources Research Institute (NRRI), (2)University of Minnesota Duluth

Tire wear particles (TWPs) are ubiquitous in urban aquatic environments, yet the fate of TWP leachates and transformation products is poorly understood. While much attention was given to the tire-derived organic pollutant (TDOP) transformation product 6PPD-quinone (6PPDQ) as the toxicant responsible for mortality in coho salmon in the Pacific Northwest (PNW), emerging evidence suggests other fish species may be sensitive to 6PPDQ and that the adverse ecological impacts of TDOPs may be more geographically widespread than previously thought. Mortality of juvenile brook trout was observed in a stream impacted by urban runoff

(Tischer Creek, Duluth, MN) in 2023 after similar meteorological conditions as those observed in the PNW (i.e., a prolonged dry period followed by a large rain event). Thus, this site was chosen as a case study to distinguish chemical indicators of tire-derived contamination. The goal of this research is to demonstrate a screening level approach to inform decision making to mitigate exposure to harmful contaminants, including site prioritization for enhanced monitoring and stormwater best management practice installation. High-resolution mass spectrometry features of TDOPs were identified by generating model TWPs from a variety of spent tires and comparing to a standard reference material comprised of a composite of unused tires. Subsequently, field evaluations were performed to verify that the TDOP features were detected in samples from a runoff-impacted urban stream. Additional non-target analyses was performed on archived samples to further characterize the TDOP signature. A greater abundance and number of contaminants were found in Tischer Creek sediment samples, suggesting that TDOPs accumulate and persist in the sediment. This implies that grab water samples will be insufficient for screening waterbodies for tire-derived contaminants as they may miss contaminants in sediments and contaminants that are only present after storm events. Coupling sediment samples with passive samplers may be more effective for screening TWPs and TDOPs in aquatic systems. Once candidate locations for enhance monitoring are identified, conventional grab sampling and target analysis during rain events can be used to determine event mean concentrations and establish the quantitative risk of contaminants to aquatic organisms.

Disclaimer/Disclosure: Funding for this project was provided by the Minnesota Environment and Natural Resources Trust
Fund as recommended by the Legislative-Citizen Commission on Minnesota Resources (LCCMR).

4.17.T-03 6PPD-Quinone Concentration and Transport Dynamics in Urban Salmonid Habitat

Mason D. King[1], Timothy F. M. Rodgers[2], Xiangjun Liao[3], Andrew R. S. Ross[3], Lisa Loseto[3], Nikki Kroetsch[3], Angela Duso[4], Kevin Soulsbury[5], David Hasman[4], Felix Oullet[6], Agnes Richards[6], Rachel Scholes[2] and Tanya Brown[1] (1)Simon Fraser University, (2)University of British Columbia, (3)Fisheries and Oceans Canada, (4)British Columbia Institute of Technology, (5)British Columbia Intitute of Technology, (6)Environment and Climate Change Canada

Numerous aquatic taxa have been assessed for adverse effects from exposure to 6PPD-Quinone (-Q). Those tests have demonstrated acute mortality at environmentally relevant concentrations in certain salmonid species, including coastal cutthroat trout (Oncorhynchus clarkii clarkii) and coho salmon (Oncorhynchus kisutch) that inhabit coastal lowland streams of the northeast Pacific Ocean. Our research further characterizes salmonid 6PPD-Q exposure in that region with a focus on urban streams. We conducted stream monitoring at five catchments in the greater Vancouver, British Columbia area from 2023 through 2025. Rainfall, stream discharge, and water sample 6PPD-Q concentration by LS-MS/MS was continually measured, commencing during dry weather and continuing for three days after the onset of wet weather to generate triplicate time series at each catchment. This presentation synthesizes that time-integrated data to report on indicators of toxicological risk, characterized by time-averaged concentrations and benchmark thresholds, as well as mass transport, and how those are influenced by hydrologic and geospatial factors. Following the onset of wet weather, 6PPD-Q frequently reached concentrations (24-hour average 39 ng/L) associated with mortality in laboratory studies with O. kitsutch and O. clarkii clarkii (i.e. 24-hour mortality), as well as multi-hour

exceedances of toxicity benchmarks (e.g. mean 8 hours ≥40 ng/L 24-hour LC50 mortality benchmark) and water quality guidelines. Applying water quality guidelines to samples taken during dry weather baseflow failed to indicate hazard observed during subsequent wet weather and 6PPD-Q flushing, when water quality guidelines were universally exceeded. Season influenced 6PPD-Q concentrations, and further analysis of hydrological variables and catchment geospatial features suggests that 6PPD-Q concentrations may depend on recent rainfall and a stream's ability to dilute urban stormwater. Catchment export of 6PPD-Q on a mass basis occurred predominantly during wet weather (mean 0.6 g/day), approximately 100-fold greater than loads during baseflow conditions, which may be influenced by the proportion of freeways within the drainage. These and other findings from our study of time-resolved 6PPD-Q dynamics provide insights that can support risk assessments for aquatic species, inform the design and interpretation of tire-additive toxicity tests, and enhance strategies for monitoring 6PPD-Q in the environment.

4.17.T-04 Developing a Conterminous U.S. 6PPD-Quinone Sources Heat Index

Brianna Williams[1], Stephanie Gordon[1], Daniel Jones[1], Rachael Lane[1], Justin Greer[1], Kelly Smalling[1] and John Hansen[1] (1)U.S. Geological Survey (USGS)

6PPD-quinone (6PPDQ) is an ozone-transformed product of 6PPD, a chemical used to increase the longevity of rubber products, including tires. In recent years, 6PPDQ has been linked to urban runoff syndrome, particularly for salmon and trout species. Increased field efforts to characterize the environmental occurrence of 6PPDQ have highlighted the need for geospatial tools to identify priority areas and potentially high-risk watersheds with elevated concentrations.

To support various sampling initiatives, known and suspected 6PPDQ sources and relevant basin characteristics were summarized at National Hydrography Dataset 1:100,000 scale (NHDPlus V2.1) catchments. National datasets including traffic counts, truck stops, tire-handling facilities, roads, airport runways, average antecedent dry days, road-stream crossings, basin runoff, and other data were first summarized and normalized by catchment. Normalized values were scaled from zero to one across all NHDPlus V2.1 catchments. Weights developed by subject matter experts were assigned to various road and airport types, and then applied to the scaled values. Finally, values were summed by catchment, and the heat index was mapped. This first iteration of the conterminous-U.S. effort was originally completed in 2025 and had a maximum heat index value of 3.06, a minimum heat index value of zero, and a mean heat index value of 0.23 across more than 2.6 million NHDPlus V2.1 catchments. Current efforts are underway to refine this heat index at both regional and national scales using improved knowledge on sources and weights, improved datasets, field validations, and by incorporating known vulnerability of multiple fish species.

4.17.T-05 Historical Emissions of 6PPD Quinone From Sediment Cores in British Columbia Lakes

Tim Rodgers[1], Simon Drew[1], Zoe Salinas-Rodriguez[2], Louis Wagner[3], Gopal Sharma[4], Mark Louie Lopez[5], Christopher Hebda[6] and Rachel Scholes[4] (1)University of British Columbia (UBC), (2)Universtity of British Columbia, (3)ALS Environmental Canada, (4)University of British Columbia, (5)University of Victoria, (6)Hakai Institute

6PPD-quinone (6PPDQ) is a transformation product of an anti-degradant used in vehicle tires that is acutely lethal to several species of salmonids. The parent compound of 6PPDQ, 6PPD, has been used in car tires for

decades, likely resulting in long-term exposures of aquatic organisms to 6PPDQ. However, there is a lack of historical data on 6PPD or 6PPDQ occurrence in the aqueous environments due to the recent discovery of 6PPDQ as the causal toxicant in salmonid mortality. Lakes act to accumulate sediment from across a watershed, and may therefore be able to provide a record of watershed 6PPDQ loadings. Thus, lake sediment cores may give a long-term quantitative or semi-quantitative view of the initial appearance and subsequent changes of 6PPDQ inputs to a watershed.
We collected sediment cores from three lakes in British Columbia, Canada with varying degrees of urbanization, ranging from 3 - 83% imperviousness in their watersheds. Sediment core dating was conducted by the University of Waterloo Environmental Isotope Laboratory. The average age of the deepest datable core segment was 1948 in Deer Lake, 1998 in Struma Lake, and 1971 in Elk Lake. Concentrations of 6PPDQ in each core correlated with their degree of urbanization, with the highest levels of up to 1000 ng/g organic carbon found in Struma Lake and the lowest levels in Elk Lake. Annual 6PPDQ deposition rates were calculated as the product of sediment 6PPDQ concentrations, sediment deposition rates, lake surface area, and lake focusing factor. 6PPDQ deposition rates in 2024 for the modern sediment at the top of each core were 4.2 g/yr for Struma Lake, 6.1 g/y for Deer Lake, and 1.1 g/y for Elk Lake. For Deer and Struma Lake, these loadings represented ~1-3% of estimated total maximum emissions of ~ 230 g/yr based on traffic in the catchments. Metals analysis using ICP-MS revealed relatively strong correlations between 6PPDQ concentrations and the concentration of antimony and zinc in both the Deer and Elk Lake cores, while for the Struma Lake core we observed a moderate positive correlation with antimony and a negative correlation with zinc. Overall, these data provide the first known historical record of 6PPDQ in sediment cores and provide an indication of the timescales on which 6PPDQ concentrations increased in urban aqueous environments. These analyses are valuable for understanding chronic exposures for local fish populations and how exposures may have evolved over time.

From Tread to Watershed: How Tire Wear Particles and Chemicals Affect Aquatic and Terrestrial Ecosystems

4.17.P-Tu231 Tire and Road Wear Particles As Vectors of Hydrophobic Tire Additives in Urban Road Environments

Yingjia Chen[1], Xinyu Du[1], Xiaojun Liu[2], Ge Yin[3], Bo Yuan[4] and Tian Lin[1] (1)College of Oceanography and Ecological Science, Shanghai Ocean University, (2)Université de technologie de Compiègne, ESCOM, Alliance Sorbonne Université, TIMR, (3)Shimadzu (China) Co., LTD, (4)Norwegian University of Science and Technology (NTNU)

Tire and road wear particles (TRWPs) are an important source of microplastics and tire-derived chemicals in urban environments, yet the role of environmentally derived TRWPs in transporting hydrophobic tire additives remains poorly understood. A large-scale separation protocol was developed and applied to isolate gram-scale TRWPs from urban road dust and roadside soils collected across multiple road environments in Shanghai, China. The amount of isolated TRWPs ranged from 0.82 to 250 mg/g in road dust and 9.3 to 21 mg/g in roadside soils, providing sufficient materials for the determination of representative hydrophobic tire additives, chlorinated paraffins (CPs, C6-C20). CP concentrations in environmental TRWPs ranged from 110 to 290 μg/g, approximately one order of magnitude higher than those in bulk road dust and soils. Strong similarities in CP homologue fingerprints between road dust and corresponding TRWPs indicated a shared source relationship. An exponential relationship (R2=0.95) between TRWP abundance and CP contribution rates demonstrated that

TRWP levels largely govern CP contamination in road dust. TRWPs contributed, on average, 38% of total CPs in road dust and 9.8-24.8% in roadside soils, with broader-scale estimation suggesting contributions of 15-36% in urban road dust and >44% in TRWP-rich environments. These results provide the first quantitative evidence that environmentally derived TRWPs act as major particulate vectors of hydrophobic tire additives in urban environments.

Disclaimer/Disclosure: Supported by the Foundation of Key Laboratory of Yangtze River Water Environment (YRWEF202502), NSFC (42107400), and Chenguang Program (22CGA57).

4.17.P-Tu232 Where the Rubber Meets the Road: Knowledge Gaps and Advancements in Understanding the Ecotoxicity and Transformation of P-Phenylenediamines

Rebecca Dalton[1], Kaiqi Yao[1], Katrina Sullivan[1], Ciara Latendresse[1] and Magdalena Jagla[1] (1)Environment and Climate Change Canada (ECCC)

Substituted p-phenylenediamines (PPDs) are widely used as antioxidants and antiozonants in tires and other rubber products. Considerable attention has been given to the 6PPD transformation product 6PPD-quinone given its high inherent toxicity to some salmonids. Assessment activities have been initiated in several jurisdictions, including Canada where 6PPD, its transformation products (notably 6PPD-quinone), and related PPDs have been identified as priorities for assessment under the Canadian Environmental Protection Act, 1999. While research on 6PPD and 6PPD-quinone has rapidly advanced in the last 5 years, research on the characterization, detection, fate, transport, and ecotoxicity of other PPDs is far less developed. This presentation will highlight PPDs as a proposed class of related substances for regulatory assessment, grouped in terms of commercial use, chemical structure and potential to form harmful transformation products. The presentation will provide an overview of the current state-of-science of PPDs and their transformation products in relation to 6PPD and 6PPD-quinone, with an aim to highlight recent advancements and current knowledge gaps.

4.17.P-Tu233 Depth-Resolved Fluvial Transport of Tire and Road Wear Particles

Hannah Hapich[1], Meredith Evans Seeley[2], John Perna[1], Jael Ochoa[1] and Andrew B. Gray[1] (1)University of California, Riverside, Environmental Sciences Department. Riverside, CA., (2)Virginia Institute of Marine Science (VIMS), William & Mary. Gloucester Point, VA.

Rivers and estuaries are the major conveyance pathway for terrestrial plastics into marine waters. Many surface water monitoring studies that analyze tire and road wear particles (TRWPs) are adapted from general microplastics monitoring and only sample shallow surface waters. This is at odds with the fundamental mechanics of riverine particulate transport, which results in plastic particle concentrations varying as a function of depth under a wide range of flow and particle characteristics. In this study, we analyze how size-resolved concentrations of TRWPs change across the depth profile in the Los Angeles (LA) River. The LA River has a channelized streambed and slow (0.93 m/s) steady flows during low flow conditions, which have the potential to emphasize particle stratification across the water column. Samples were collected at 5 discreet depths using a paired sampling approach: (1) a handheld bedload sampler with a net to capture coarse particles >100 µm, and (2) an isokinetic sampler to capture bulk water samples (~1 L) to analyze fine particles <100 µm. Flow rates were measured at each depth to compare the velocity depth profile with particle concentrations. Samples underwent an organic matter digestion and size classification, with coarse particles quantified by count, and fine

particles filtered onto glass fiber filters for mass quantification. All filters and a subset of visually identified coarse particles underwent pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS) analysis. Results suggest the concentration of very coarse (>250 µm) TRWPs increases as you get closer to the bed (18-28 particles/m3). Conversely, fine (<100 µm; 118-304 µg/L) and ultrafine (<20 µm; 3-16 µg/L) TRWP concentrations decreased with depth, suggesting aerial deposition on the water's surface, where the hydrophobicity of these particles cause them to travel primarily as surface load despite their density. This research helps bridge the gap from experimental work into environmental monitoring, in addition to having implications on flux estimates into marine and estuarine environments. Namely, if most river flux estimates of TRWPs have relied on surface water concentrations, current calculations of total coastal loading may be underestimated for coarse particles or overestimated in studies where the fine particle fraction is analyzed.

4.17.P-Tu234 Assessing the Environmental Risk of Tire Wear Particles: Multi-Species Acute Toxicity and Threshold Estimation for USTMA CMTT

Kei Nakayama[1], Masaki Sakamoto[2], Akihiko Hata[2] and Seiichi Uno[3] (1)Ehime University, (2)Toyama Prefectural University, (3)Kagoshima University

Tire wear particles and their associated chemical additives, which can transform into highly toxic compounds such as 6PPD-quinone upon environmental release, represent a complex and significant hazard to aquatic ecosystems. Characterizing these risks is fundamentally challenging because toxicity may be driven by both particulate and dissolved phases, and variations in sample preparation can significantly alter outcomes. To address the critical need for comparable, multi-species data generated with standardized materials, this study evaluated the acute toxicity of a common reference material—USTMA cryogenically milled tire tread (CMTT)—across a diverse range of aquatic taxa. Ultimately, we aimed to compare the effects of particle suspensions versus filtrates/leachates and to estimate a protective threshold based on a species sensitivity distribution (SSD).

We conducted standardized acute toxicity tests using CMTT particle suspensions (8.0–12.5 g/L) and their corresponding leachates. The test organisms included fish early life stages (Misgurnus anguillicaudatus, Oncorhynchus mykiss, Oryzias latipes, and O. javanicus), crustaceans (Daphnia magna), insects (Chironomus yoshimatsui), and algae (Raphidocelis subcapitata). The results revealed pronounced interspecies variability in sensitivity, with O. javanicus and C. yoshimatsui proving particularly vulnerable. For instance, the 4-day LC50 for O. javanicus exposed to suspensions was 0.081 mg/mL, indicating an approximately 20-fold higher sensitivity compared to O. latipes. Furthermore, significant differences in toxicity were observed between exposure phases; D. magna exhibited a 48-h EC50 of 547 mg/L in suspension compared to a less toxic 1410 mg/L in the filtrate, demonstrating that the presence of the particle phase critically influences effect estimates. By compiling these acute LC50 and EC50 values, an SSD was constructed, yielding a hazardous concentration for 5% of species (HC5) of 6.44 mg/L. The inclusion of a supplementary chronic amphipod dataset further reduced the HC5 to 3.19 mg/L. These findings underscore the necessity of clearly distinguishing between particle-phase and dissolved-phase exposures in both experimental design and ecological risk assessment. Moving forward, the accumulation of chronic toxicity endpoints across multiple taxa will be essential to refine SSDs and establish robust, real-world ecological risk frameworks for tire-derived chemical mixtures.

Disclaimer/Disclosure: This research was supported by the Environmental Research and Technology

Development Fund (No. 1-2204: JPMEERF20221004; No. 1-2502: JPMEERF20251002) of the Environmental Restoration and Conservation Agency and the Ministry of the Environment of Japan.

4.17.P-Tu235 Interspecific Differences in Effects on Fish Exposed to Tire Wear Particles

Seiichi Uno[1], Tatsuya Bito[1], Masatoshi Yamasaki[1], Emiko Kokushi[1] and Kei Nakayama[2] (1)Kagoshima University, (2)Ehime University

Since the serious effects of 6-PPD quinone, derived from a tire component, on coho salmon was clarified in 2021, research on the biological effects of tire particulates has become active. Subsequently, it has been revealed that the influences of tire particulates are induced not only by 6-PPD quinone, but also by its isomers and related compounds, and even by the parent compound 6-PPD. However, the effects of substances derived from tires on aquatic organisms, except for 6PPD and the derivatives, have been infrequently examined, although tires themselves are manufactured from more than one hundred chemicals and contain toxicants such as polycyclic aromatic hydrocarbons and zinc. Therefore, additional substances might present unexpected toxic effects in organisms. In fact, we already confirmed the certain effects on freshwater and marine amphipod exposed to suspension and leachate of tire wear particles only included slight amount of 6-PPD. In the present study, we obtained Cryo-Milled Tire Tread (CMTT) produced by U.S. Tire Manufacturers Association. Then, rainbow trout (Oncorhynchus mykiss), are sensitive to 6-PPD quinone, Japanese medaka (Oryzias latipes), and Java medaka (Oryzias javanicas) treated as test marine fish were exposed to the test water suspended CMTT or the leachate collected from suspension of CMTT, and compared each effect exhibited in individual species.

One- (pre-flexion period) and three-week (post-feeding) larvae post-hatch of rainbow trout and 2-week for Japanese and Java medaka were prepared, and they exposed to suspension or the leachate for 14 days, although the period was only 1 week for one-week larvae.

The exposures of leachate collected from 12.5 mg/mL for CMTT suspension caused 100% mortality of all species within 2 days after starting exposures. Fish could survive almost without mortality in leachate under 2.5 mg/mL. On the other hand, the effects for exposure of suspension showed remarkably interspecific differences. LC50s for 96hr were 0.981 and 0.766 mg/mL for 1- and 3-week rainbow trout, and 1.83 mg/mL for Japanese medaka, respectively, and they were roughly similar. Meanwhile, the LC50 for Java medaka was 0.081 mg/mL and were approximately 5 to 10 folds smaller than those for rainbow trout and Java medaka. The reason of differences is not recognized. But 6-PPD quinone in CMTT is small concentration, and perhaps other substances with a certain difference for toxicities depending on species.

4.17.P-Tu236 Microscopic Tire Particles in Oysters: Linking Uptake, Retention, and Environmental Stressors

John Weinstein[1], Bonnie Ertel[2], Jessica Wenclawiak[3] and Gabrielle Jones[4] (1)Citadel, (2)University of South Carolina, (3)Consolidated Safety Services (CSS), (4)College of Charleston

The widespread occurrence of tire and road wear particles (TRWPs) in estuarine systems has raised growing concern regarding their persistence, bioavailability, and potential transfer through coastal food webs. Although oysters are known to accumulate microplastics from the water column, their role in the environmental fate and retention of tire-derived particles remains poorly understood. In this study, we synthesized a series of controlled laboratory exposures examining uptake and depuration kinetics of microscopic tire particles in the Eastern oyster, Crassostrea virginica, using micronized crumb rubber as a surrogate for TRWPs. Across both single-

particle and mixed-particle toxicokinetic studies, crumb rubber consistently exhibited greater accumulation and prolonged retention in oysters relative to fibers and fragments. Complementary experiments further demonstrated that elevated temperature and co-exposures between Vibrio vulnificus with microplastic fragments significantly increased accumulation and prolonged retention, highlighting the possible role of environmental stressors in controlling TRWP fate in oysters. Depuration patterns were generally best described using two compartment kinetic models, indicating that tire particles may partition into both rapidly cleared and longer-term retention compartments within oysters. Collectively, these findings suggest that oysters may serve not only as passive indicators of TRWP contamination, but also as biologically-mediated retention reservoirs capable of prolonging the trophic availability of tire-derived contaminants in estuarine ecosystems. This work underscores the importance of considering environmental change, pathogen exposure, and particle-specific behavior when evaluating the ecological and seafood safety implications of microscopic tire particles in coastal environments.

4.17.P-Tu237 An Exposure Model for Quantifying Releases of Additives From Tire Wear Particles: A Case Study of 6PPD and 6PPD-Quinone

Cindy X. Yang[1], Mathieu Dextraze[1], Mohamed Ahmed[1], Danaëlle Delâge[1], Kaiqi Yao[1], Katrina Sullivan[1], Ciara Latendresse[1], Rebecca Dalton[1] and Magdalena Jagla[1] (1)Environment and Climate Change Canada

Tire wear particles (TWPs) are increasingly recognized as a significant source of contaminants in aquatic environments. One category of additives used in tire formulations are antioxidants and antiozonants, particularly N-(1,3-dimethylbutyl)-N′-phenyl-p-phenylenediamine (6PPD). Through reaction with atmospheric ozone, 6PPD can be transformed into 6PPD-quinone, a compound associated with acute toxicity in some salmonids. Both 6PPD and 6PPD-quinone together with TWPs can be released into the environment. Despite growing concern over tire-derived contaminants, quantitative exposure models capable of predicting their environmental concentrations under diverse urban conditions remain limited.

A new probabilistic mass-balance model was developed by Environment and Climate Change Canada to estimate concentrations of tire-derived antioxidants and antiozonants, and their transformation products in stormwater and snowmelt runoff from urban watersheds. The model integrates TWP emission rates, watershed characteristics, meteorological conditions, chemical-specific physicochemical properties, chemical transformation kinetics, leaching behavior, and treatment removal efficiencies. Atmospheric oxidation of p-phenylenediamine antioxidants to quinone transformation products is explicitly represented. Variability and uncertainty were characterized using Monte Carlo simulation with one million iterations.

The model was parameterized for major urban watersheds in Canada, including the Greater Toronto Area, Metro Vancouver, and Greater Montreal. Predicted environmental concentrations of 6PPD-quinone in receiving waters from stormwater runoff events and snowmelt runoff were generally consistent with concentrations reported in Canadian monitoring studies that documented 6PPD-quinone concentrations ranging from tens to hundreds of ng/L in urban receiving waters.

Results indicate that the model captures key processes governing the generation, transformation, mobilization, and transport of tire-derived contaminants and provides environmentally realistic exposure estimates. The model can be adapted to evaluate other tire additives and transformation products, supporting evaluation of

exposure and ecological risk assessment of tire-derived chemicals in urban aquatic environments.

4.17.P-Tu238 Direct Injection LC-MS/MS for High-Throughput Monitoring of Tire and Road Wear Particle-Derived Contaminants in Urban Runoff and Surface Waters

Holly Lee[1], Hitha PP[1] and Sashank Pillai[1] (1)SCIEX

The application of N-(1,3-dimethylbutyl)-N′-phenyl-p-phenylenediamine (6-PPD) as an antioxidant in tire manufacturing has resulted in the widespread occurrence of a class of tire and road wear particle (TRWP)–derived chemicals, which include 6PPD-quinone (6PPD-Q) as the ozonation metabolite, other structurally similar PPD-quinones and tire additives such as hexa(methoxymethyl)melamine (HMMM). The transport of these compounds into surface and stormwater systems via urban runoffs has raised significant concern due to their persistence and aquatic toxicity, necessitating sensitive and robust analytical methods for quantitation. In this study, a rapid and high-throughput direct injection LC-MS/MS method was developed for the simultaneous quantitation of 6PPD-Q, 7PPD-Q, DPPD-Q, CPPD-Q, IPPD-Q, 4-hydroxydiphenylamine (4-HDPA) and HMMM in aqueous matrices on the SCIEX 6500+ system. The method employs a dilute-and-shoot workflow, eliminating the need for extensive sample preparation such as solid-phase extraction, thereby minimizing sample handling and contamination risk and enabling increased analytical throughput. Chromatographic optimization of the gradient and mobile phase conditions using a reversed-phase C18 column yielded good separation of all analytes, while detection was performed in multiple reaction monitoring (MRM) mode with 2 transitions optimized per analyte. Method performance was evaluated in reagent water, lake water and road runoff, demonstrating good linearity (r2 >0.99), accuracy (80–120%) and precision (%CV <20%) at sub ng/mL limits of quantitation (LOQs). The direct injection approach offers a simple and rapid workflow for high-throughput monitoring of 6PPD-Q and related compounds in water, supporting the ongoing need to better understand the occurrence, fate and risk of TRWP-derived chemicals in the aquatic environment.

4.17.P-Tu240 Targeted and Non-Targeted Screening of Tire-Derived Contaminants in Water and Passive Sampler Extracts

Rheina Hawabhay[1], Elli Hung[1], Hugo Marchand[1], Jessica Head[1], Morgan Solliec[2] and Stéphane Bayen[1] (1)McGill University, (2)Ministry of the Environment, the Fight against Climate Change, Wildlife and Parks (MELCCFP)

Tire-derived chemicals such as N-(1,3-dimethylbutyl)N’-phenyl-p-phenylenediamine (6PPD) and its transformation product 6PPD-quinone (6PPD-Q) have emerged as priority targets in urban aquatic environments. Their occurrence is often episodic with a strong dependence on hydrological conditions including flow variability and dilution effects which complicates monitoring using conventional grab sampling approaches.

A key challenge in characterising these chemicals is the limited ability of discrete sampling to capture the release pulse associated with run-off driven mobilisation. While passive sampling has recently been demonstrated as a promising strategy for the monitoring of 6PPD-Q, its potential to enhance chemical coverage for the comprehensive quantification and non-targeted screening remains largely underexplored. This study therefore evaluates the use of polar organic chemical integrative samplers (POCIS) as enrichment tools for the simultaneous targeted and non-targeted analysis of tire derived contaminants in surface waters in Quebec. It is hypothesized that passive sampling will increase the detection frequency and chemical coverage with respect to

tire-derived contaminants.
POCIS samplers were deployed across various freshwater streams comprising both high flowrate rivers and smaller tributaries to capture a wide range of environmental and spatial variability. For comparison, grab samples were also collected in parallel following rain events. Furthermore, controlled laboratory experiments using the POCIS were conducted using spiked surface water to investigate compound specific behaviour and determine their sampling rates.
The samples were analysed using ultra high-performance liquid chromatography coupled with high-resolution mass spectrometry (UHPLC-HRMS). Targeted quantification of 6PPD-Q and 17 other structurally related compounds was performed using isotopically labelled internal standards. Non-targeted screening was applied to evaluate whether passive sampling enhances the detection of previously uncharacterised tire-related transformation products, and other co-occurring chemicals.
By coupling time-integrated sampling with HRMS, the study investigates the suitability of passive sampling as a platform for broad chemical screening. The integrated approach provides deeper insights on the potential usage of passive samplers for the non-targeted analysis of tire-derived chemical as well as their mobilisation in the environment.

4.17.P-Tu241 Local Hydrology, Watershed Size, and Storm Dynamics Influence the Spatiotemporal Occurrence and Distribution of 6PPD-Quinone in the Chesapeake Bay Watershed

Rachael Lane[1], Rebecca Gorney[1], Stephanie Gordon[1], Brianna Williams[1], Tristan Mohs[1], Leah Staub[1], Justin Greer[1], Natalie Hall[1], Joseph Duris[1], Daniel Jones[1] and Kelly Smalling[1] (1)U.S. Geological Survey (USGS)

The Chesapeake Bay, home to over 3,600 species of plants and animals, is the largest and most economically significant estuary in the United States. Rapid urbanization across the 165,000 square kilometer watershed has increased impervious surfaces as the regional population has grown to more than 18 million people. Vehicles traveling on these impervious surfaces contribute to contamination under normal driving conditions, as friction between rubber tires and roadways causes the accumulation of microscopic tire particles, which can then be transported to local streams during storm events. One of the most toxic chemicals known to affect aquatic animal life, and of potential concern to the imperiled brook trout of the Chesapeake Bay watershed, is 6PPD-quinone (6PPDQ), a transformation product of the tire antioxidant 6PPD.
This study provides an initial evaluation of 6PPDQ occurrence and potential exposure across the Chesapeake Bay watershed under a range of hydrological and landscape conditions. Sampling sites with potentially elevated 6PPDQ ecosystem risk were identified using the national U.S. Geological Survey 6PPDQ geospatial heat index, which summarizes known and suspected sources of 6PPDQ. More than 200 samples were collected from 39 sites in the watershed under varying flow regimes from 2019-2026. 6PPDQ was detected in 66% of samples and was present at 26 of 39 sites, with concentrations ranging from 0.264 to 742 ng/L. Occurrence patterns were influenced by local hydrology, watershed size, and storm dynamics, highlighting the need for refined, site specific assessments, particularly in sensitive habitats or areas of conservation concern. Concentrations rarely reached levels associated with brook trout acute mortality (LC50 100-590 ng/L); however, the findings raise concerns about chronic exposure, especially during storm events when concentrations are elevated. These results can help prioritize habitat protection and inform stormwater management strategies to reduce instream 6PPDQ concentrations.

4.17.P-Tu242 6PPD-Quinone in Maine Streams

Tom Danielson[1] (1)State of Maine - Department of Environmental Protection (DEP)

Maine is one of the last remaining strongholds for wild, self-reproducing populations of Brook Trout in the United States. Laboratory studies have shown that 6PPD-quinone is toxic to Brook Trout. For example, two studies found that LC50 values (24 hours of exposure) for fry and year-old Brook Trout were 100 and 590 ng/L, respectively. In 2024, the U.S. Environmental Protection Agency set an acute screening value of 11 ng/L (ppt) to protect aquatic life, including Brook Trout. In 2024 and 2025, the Maine Department of Environmental Protection (DEP) collected water samples in streams to determine 6PPD-quinone contamination in Maine's streams and potential risk to Brook Trout. In 2024, DEP collected water samples from 38 sites near roads with high traffic volume. Sample collection was not timed to coincide with rainstorms. Concentrations of 6PPD-quinone exceeded the screening value in five urban streams. In 2025, DEP collected samples at five urban streams during rainstorms. Nearby streams support populations of Brook Trout so it is thought that these streams also supported Brook Trout in the past. At each site, staff collected one sample before the storm and seven samples after it started raining. At two of the five sites, rainfall was light and concentrations of 6PPD-quinone remained below 11 ng/L. At the other three locations, rainfall was intense and 6PPD-quinone concentrations were greater than 11 ng/L. Mean and maximum concentrations ranged from 66-519 and 117-776 ng/L respectively. For these three storms, concentrations went up and back down over a period of several hours. This study found that sufficiently intense rainstorms can cause 6PPD-quinone to exceed recommended screening values to protect aquatic life.

4.17.P-Tu244 Detecting Rubber Derived Compounds in Soil and Sediment Using an Optimized QuEChERS Method

Phillip Berger[1], Madison McMinn[1], Katherine Poisson[1] and Zhenyu Tian[1] (1)Northeastern University

End-of-life tires are difficult to recycle chemically and often end up physically transformed into crumb rubber to be used as infill for artificial turf fields. Crumb rubber is transported from the fields to soil and water ways via natural and anthropomorphic pathways. This releases rubber-derived compounds (RDCs), a broad group of tire additives and transformation products, into the environment. With recent studies highlighting the ecotoxicological effects of some RDCs such as 6PPD-quinone and 4-hydroxydiphenylamine, new methods to extract RDCs from complex environmental matrices have become critical for risk assessment. While progress has been made on analyzing RDCs in water, the absence of a comprehensive extraction method for RDCs in soil hinders the study of the fate and transport of these contaminants.

Two popular extraction methods, accelerated solvent extraction (ASE), and quick, easy, cheap, effective, rugged, and safe (QuEChERS), were chosen as the starting points for the optimization process. Extraction optimization success was gauged by recovery using a mixture of 30 RDCs containing antioxidants, vulcanizing agents/accelerants, cross linking agents, and plasticizers. Initial recovery testing for ASE involved fractionation and solvent testing. QuEChERS proved to have a better baseline recovery (median absolute recovery = 46%) than ASE (median absolute recovery = 27%) and the project shifted to optimize this method over ASE. QuEChERS optimization included pH, soil mass, in-line clean-up sorbents, temperature, and hydration times. This optimization resulted in a median absolute recovery of 74% and median relative recovery of 101% for 19 RDCs. The optimized QuEChERS method was used to analyze soil samples gathered from sites surrounding artificial turf fields in Massachusetts (n=4), roadside dust samples (n=3), and sediment samples gathered from

tire reefs (n=2). Results show trends of increasing concentrations in soil following field replacement, and variability of certain RDCs depending on the matrix analyzed.

4.17.P-Tu245 Background 6PPD-Quinone Levels in Urban Streams and Emerging Soil/Sediment Methods

Louis Wagner[1] (1)ALS Environmental Canada

6PPD-quinone [6PPD-Q], a transformation product of the tire antioxidant 6PPD, has rapidly become a priority contaminant for stormwater, urban stream, and receiving-environment monitoring. While much of the early focus has been on acute “first-flush” runoff events, less attention has been given to the question of background concentrations in urban streams during dry-weather or low-flow conditions. Understanding these baseline levels is important for evaluating chronic exposure potential, determining fit-for-purpose reporting limits, and designing monitoring programs that can distinguish acute runoff pulses from persistent urban background conditions.

This presentation will summarize collaborative monitoring conducted with the North Shore Streamkeepers in Wagg Creek, North Vancouver. First-flush samples collected following a dry period confirmed elevated 6PPD-Q concentrations in the hundreds of ng/L range, consistent with stormwater-driven transport and well above current acute guideline levels. However, follow-up sampling under baseline, low-flow conditions also demonstrated measurable 6PPD-Q across multiple locations, generally in the low ng/L range. These findings suggest that background concentrations in urban streams are not necessarily zero, even when direct road-runoff influence is minimized, and that routine low-level analytical sensitivity may be sufficient for many urban background monitoring applications.

The presentation will also discuss possible contributors to these background concentrations, including delayed release from urban catchments, sediment interaction, atmospheric particulate deposition, and rainfall as a secondary transport pathway. Finally, emerging analytical approaches for soil and sediment matrices will be reviewed, including solvent extraction methods for total extractable 6PPD and 6PPD-Q and water-leachable methods intended to assess the fraction of 6PPD-Q that may partition from solids into water. These developing methods support a broader understanding of soils, sediments, road dust, and other solid matrices as potential reservoirs, transport media, and recurring sources of 6PPD-Q to urban aquatic environments.

4.17.P-Tu246 Metabolism of 6PPDQ in Salmonids: The Quantitation of Key Metabolite Groups

Denis da Silva[1], Li-Jung Kuo[1], Gunnar Goetz[1], Jeff Atkins[1], Julann Spromberg[1], Christopher Tatara[1], Nathaniel Scholz[1] and Irvin Schultz[1] (1)NOAA

6PPDQ continues to pose risks to salmonid species due to its presence in urbanized watersheds. A better understanding of the uptake and disposition of 6PPDQ among salmonids with diverse sensitivity to this chemical is important to help unraveling interspecies differences in toxicity. Our study focuses on assessing 6PPDQ uptake and metabolism between a highly sensitivity species, coho salmon (Oncorhynchus kisutch), and a relatively less sensitive species, steelhead (Oncorhynchus mykiss). Fish were exposed to 6PPDQ via a static waterborne system up to 96 hours. All individual exposure tanks had a loading density near 1g fish/L water.

Water samples were collected throughout the experiments. At termination times (1, 2, 4, 12, 24, 48, and 96 hours), fish were euthanized, followed by sampling of blood, bile, liver, and carcass. The use of a static water exposure system permitted mass balance calculations on the disposition of 6PPDQ. Our laboratory has developed different protocols for measuring 6PPDQ in fish tissues and water, all showing satisfactory analytical efficiency, sensitivity and reproducibility. Recently we develop a method for quantitation of phase I metabolites of 6PPDQ via liquid chromatography/tandem mass spectrometry (LC-MS/MS). To obtain instrument's calibration curve and response factor, as well as test extraction efficiency, we used pure standards of hydroxylated-6PPDQ representing 3 different groups: aryl-hydroxy-, alkyl-hydroxy- and aryl-alkyl-dihydroxy-6PPDQ metabolites. Stability tests of 6PPDQ in the exposure system without fish demonstrated no loss up to 96 hours. No statistical differences in 6PPDQ uptake were seen between coho and steelhead. Approximately 80 % of 6PPDQ was absorbed from the water by the end of the 96-h experiments. Measured 6PPDQ in bile, plasma, liver and carcass only account for up to 10 % of the 6PPDQ loss from the water. When 6PPDQ metabolites were measured, particularly in bile, we determined metabolism of this chemical was the primary route of elimination and accounts for the vast majority of the 6PPDQ loss from water. We are assessing potential differences associated to metabolism rate for each specific metabolite between both species. Our data highlights the importance of measuring biliary 6PPDQ metabolites to enhance the environmental monitoring of fish exposure to 6PPDQ.

4.17.P-Tu247 Tissue-Specific Accumulation, Elimination, and Transformation of 6PPD-Quinone in Juvenile Rainbow Trout (Oncorhynchus mykiss) Subjected to In Vivo Exposures

Adam Moody[1], David Soucek[2], Rebecca Dorman[1], James Candrl[1] and David Alvarez[1] (1)U.S. Geological Survey (USGS), (2)EA Engineering, Science, and Technology Inc. PBC

The tire rubber antiozonant transformation product N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine-quinone (6PPDQ) has garnered international attention due to its ubiquitous presence in urban stormwater systems and to its acute toxicity to some salmonids while sparing other fish species. The underlying causes of this species-specific toxicity remain unresolved including significant knowledge gaps that investigate the toxicokinetic mechanisms of 6PPDQ —specifically its bioaccumulation, tissue distribution, transformation, and elimination—in sensitive species. This study explored these toxicokinetic aspects of 6PPDQ in juvenile rainbow trout (Oncorhynchus mykiss), a known sensitive species, when subjected to 96-hour in vivo exposures (N = 64) with 6PPDQ (200 ng/L, 600 ng/L, control, and solvent control). Upon completion of the 96-hour exposure period, half of the fish (n1 = 32) were immediately euthanized and dissected with their plasma, brain, eyes, gills, liver, kidney, gut (intestines + spleen), and filet (muscle) processed for sample analysis. The remaining half of the fish (n2 = 32) were subjected to a post-exposure depuration period lasting up to 168-hours, with staggered take down occurring at 24-, 48-, 72-, and 168-hours after depuration initiation. All fish removed from depuration were immediately euthanized, dissected, and processed for sample analysis in the same manner as the exposed fish not subjected to depuration. No mortality occurred to 6PPDQ exposed fish during the 96-hour exposure or the depuration period. Fish tissues were processed for targeted analysis of 6PPDQ using established analytical methods and non-targeted analysis of related transformation products in tissue was done using high-resolution LC-MS instrumentation. Predominant accumulation of 6PPDQ in tissues at the end of the 96-hour exposure occurred in the gills, gut, and eyes samples, with the lowest levels detected in plasma. Concentrations for 6PPDQ in all tissue types did not show a linear increase relating to exposure treatment. Elimination for

6PPDQ in tissues differed among tissue type and 6PPDQ was detectable in both gills and eyes tissues after 168-hours of depuration and detectable in liver tissues after 72-hours of depuration. Results are pending on the identification of 6PPDQ transformation products in specific tissues. Findings from this study offer crucial data for the toxicokinetic mechanisms that drive toxic mode of action for 6PPDQ in sensitive salmonids.

4.17.P-Tu249 Acute Toxicity of 6PPD, 6PPD-Quinone, and Potential Alternatives on Freshwater Mussels

Holly Puglis[1], Brittany Perrotta[1], Stephanie Gill[2], James Kunz[1], Rachael Lane[1] and David Soucek[1] (1)USGS, (2)Washington State Department of Ecology

Urban runoff–derived contaminants from tire wear, particularly 6PPD and its transformation product 6PPD quinone (6PPDQ), have been linked to acute mortality in coho salmon (Oncorhynchus kisutch) and may pose risks to other aquatic organisms such as freshwater mussels. Mussels are culturally and ecologically significant yet understudied regarding sensitivity to these compounds, creating a key data gap in evaluating safer alternatives to 6PPD in tires. This study compares the toxicity of alternative antiozonants with 6PPD and 6PPDQ on freshwater mussel juveniles. Acute toxicity was assessed by conducting 96-hour tests with juvenile Fatmucket (Lampsilis siliquoidea) and Western Pearlshell (Margaritifera falcata) to derive median lethal concentrations (LC50s) for each compound under controlled laboratory conditions. These findings will support evaluation of whether proposed 6PPD alternatives pose equal or lower risk to sensitive freshwater mussels and will help prevent unintended consequences from substitutions in future tire formulations. This work advances understanding of toxicity of tire derived contaminants in taxa beyond salmonids and informs chemical replacement decisions for aquatic ecosystem protection.

4.17.P-Tu250 Exploring Toxicity Pathways of 6PPD and 6PPDQ in Early-Life Stage Largemouth Bass (Micropterus nigricans)

Katryna Seabrook[1], Junyi Lin[2], Catherine Roberts[2], Markus Hecker[2], Xiangjun Liao[3], Lisa Loseto[3], Louise Winn[1] and Diane Orihel[1] (1)Queen's University, (2)University of Saskatchewan, (3)Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, British Columbia

The tire rubber antioxidant N-(1,3-dimethylbutyl)-N’-phenyl-p-phenylenediamine (6PPD) and its transformation products were recently identified as a priority for assessment under the Canadian Environmental Protection Act, 1999, due to the acute toxicity of 6PPD-quinone (6PPDQ) to some species of fishes. To further our understanding of the mechanisms underlying the toxicity and species-specific sensitivity of these chemicals, this study aimed to characterize and compare toxicity pathways of 6PPD and 6PPDQ in larval largemouth bass (Micropterus nigricans), one of the most widely distributed freshwater fish in North America. In an outdoor microcosm experiment, wild-collected bass were exposed to a range of six 6PPD or 6PPDQ concentrations (2 – 22 µg/L, nominal) alongside a solvent control (0.02% v/v dimethyl sulfoxide) using a replicated regression-based design. Exposures were conducted using natural lake water under static renewal conditions for 7 days, spanning the embryonic to early larval life stages. We found that pathway-level transcriptional responses from whole-larvae samples collected after 96 hours of exposure preceded and mechanistically aligned with organismal-level effects observed only after 7 days of exposure. While exposure to 6PPD resulted in more organismal-level effects than 6PPDQ, both chemicals induced concentration-dependent cardiovascular effects, with an increase in heart rate ($p < 0.001$) in 6PPDQ-exposed larvae and an increase in both heart rate ($p <$

0.001) and pericardial area (p = 0.03) in 6PPD-exposed larvae. Interestingly, our data showed evidence suggesting mechanistic differences behind 6PPD and 6PPDQ-induced cardiotoxicity. For example, transcriptomic analysis revealed concentration-dependent enrichment of pathways related to calcium signaling and muscle contraction in 6PPD-exposed larvae, whereas pathways related to metabolism, specifically metabolism of xenobiotics by cytochrome P450, were most enriched in 6PPDQ-exposed larvae. This presentation will further explore the integration of molecular and whole-organismal endpoints to identify causal relationships between environmentally realistic exposures and toxicological effects. Through the characterization of sublethal effects in larval largemouth bass, this work contributes to our mechanistic understanding of the toxicity and species-specific sensitivity of these emerging contaminants.

4.17.P-Tu251 Comparative Assessment of Developmental and Ocular Toxicity of 6PPD and Related Amine-Based Antioxidants in Zebrafish Embryos

Hohyun Jin[1] and Kitae Kim[1] (1)Seoul National University of Science and Technology

The acute toxicity of 6PPD-quinone, an environmental transformation product of the widely used tire antioxidant 6PPD, has raised concerns regarding the environmental risks of related amine antioxidants. In particular, para-phenylenediamine (PPD) derivatives are extensively used in tire manufacturing and can be released into environments through tire wear particles. However, previous studies have largely focused on individual compounds, and comparative toxicity data among structurally related PPD derivatives remain limited. Therefore, based on observations of reduced eye size in zebrafish exposed to 6PPD, this study aimed to compare the developmental and visual toxicity of six amine antioxidants using a zebrafish embryo model: five PPD derivatives (6PPD, IPPD, CPPD, DPPD, and DNPD) and DPA, a monoamine antioxidant. Test chemicals were dissolved in dimethyl sulfoxide (DMSO) and diluted with E2 media. Zebrafish embryos at 4 hours post-fertilization (hpf) were individually exposed in 96-well plates to five concentrations prepared by serial two fold dilution from a maximum concentration of 45 μM, with a negative control group. Hatching rate was assessed at 96 hpf, while mortality, body length, eye size, and locomotor behavior were evaluated at 120 hpf. In addition, quantitative PCR (qPCR) was performed to evaluate the expression of ten genes associated with visual development in exposure groups that did not exhibit significant mortality. Exposure to 6PPD induced concentration-dependent mortality and reduced eye size. Behavioral assessment showed decreased locomotor activity in the high-concentration groups, accompanied by altered expression of genes, including pax6a and six3a. IPPD and CPPD, which possess asymmetric alkyl–phenyl substitution patterns, exhibited toxicity profiles similar to those of 6PPD. In contrast, DPPD and DNPD, characterized by symmetric diaryl substitution, as well as DPA, did not induce mortality. Nevertheless, altered expression of several related genes was observed following exposure to these compounds, suggesting that molecular perturbations may occur prior to overt phenotypic toxicity. Overall, the results indicate that the structure and symmetry of nitrogen substituents play important roles in determining the toxicity of PPD derivatives. These findings provide new insights into structure–toxicity relationships among amine antioxidants and contribute to the ecological risk assessment of tire derived contaminants in environments.

General: Chemistry and Exposure Assessment

4.18.P-Tu260 Reliable Ultra-Trace Metals Analysis of Marine and Estuarine Waters and

Brines Using Triple Quadrupole ICP-MS

Louis Wagner[1] (1)ALS Environmental Canada

Ultra-trace metals analysis of marine waters, estuarine waters, brackish waters, and industrial brines is challenging due to high dissolved salt content, ionization suppression, sample introduction stress, and complex polyatomic interferences, particularly chloride-based species. These challenges can lead to biased results or false positives if not properly controlled, especially when assessing low-level metals against British Columbia and Canadian marine water quality guidelines.

This poster presents the use of triple quadrupole inductively coupled plasma mass spectrometry [QQQ-ICP-MS] for reliable metals analysis in saline waters. By using an additional quadrupole mass filter before the collision/reaction cell, QQQ-ICP-MS provides improved control of reaction chemistry and more selective interference removal compared with conventional single-quadrupole ICP-MS. This is particularly valuable for chloride-rich matrices, where interferences can compromise data quality.

The method enables broad multi-element analysis of saline waters without the intensive matrix removal or pre-concentration steps traditionally used for ultra-trace marine metals work. ALS seawater metals reporting limits are below relevant BC and federal marine water quality guidelines, supporting regulatory assessment, baseline monitoring, and environmental effects programs. Key sampling practices, including verified-clean containers, avoidance of metallic sampling components, clean field filtration, and appropriate blanks, are also highlighted as essential to producing defensible ultra-trace metals data.

4.18.P-Tu261 Preserving the Evidence: Evaluating Ethanol's Impact on Metal Concentrations in Benthic Invertebrates

Jennie Christensen[1], Geriene LaBine[1] and Alexandra Wade[1] (1)TrichAnalytics Inc.

Ethanol is commonly used to preserve benthic invertebrate tissues prior to analysis, yet its influence on metal concentration measurements remains largely uncharacterized. This study evaluated the effect of ethanol preservation on metal concentrations in benthic invertebrates over a 100-day period. A homogenized stock mixture of dried benthic invertebrates—prepared from excess field material—was divided into small aliquots and preserved in ethanol for varying durations. After exposure, samples were removed from ethanol, dried, and analyzed using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). A control sample, stored without ethanol under ambient conditions, was analyzed at both the beginning and end of the study to assess inherent sample stability. Results indicated that ethanol preservation had minimal effect on most metal concentrations. For example, selenium, which is a particular metal of concern in many freshwater monitoring programs, showed high stability over time in ethanol. The control selenium concentration was 55 mg/kg dry weight and the Day 100 ethanol exposure had a selenium concentration of 53 mg/kg (total RSD of ethanol samples was 12%, ranging from 50 mg/kg to 72 mg/kg). Mercury, another metal of concern, showed similar stability as selenium. The control concentration was 0.102 mg/kg and the Day 100 ethanol concentration was 0.092 mg/kg (total RSD of ethanol samples was 16%, ranging from 0.092 ppm to 0.136 ppm). Observed variations were attributed primarily to natural heterogeneity in the benthic matrix, rather than chemical alteration due to ethanol exposure. Overall, ethanol preservation does not have any impact on metal concentrations in invertebrates.

4.18.P-Tu262 Evaluating Metal Concentration Variability in Fish Muscle To Support Non-Lethal Tissue Plug Sampling

Jennie Christensen[1], Geriene LaBine[1] and Alexandra Wade[1] (1)TrichAnalytics Inc.

Environmental monitoring programs are shifting toward more sustainable, non-lethal methods. In fish, muscle tissue is the primary matrix used for assessing metal exposure for environmental monitoring programs. Traditional metal analysis requires large quantities of tissue (2–5 g wet weight), necessitating fish to be killed for sampling. However, laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) can accurately quantify metals from as little as 20–100 mg of tissue, making non-lethal biopsy plugs a viable option. This study evaluated whether a small muscle biopsy taken from a single location on a fish is representative of the entire muscle filet. Muscle samples were collected in a grid pattern every (~2 cm^2) from the filet of five Rainbow Trout and three Arctic Char and analyzed for 30 elements using LA-ICP-MS. Although full elemental profiles were assessed, results focus on selenium, mercury, arsenic, zinc, and copper. Results show that metal concentrations across a whole fish filet were generally homogeneous, specifically for selenium and mercury. On average across all fish analyzed, 95% of samples on a fish fillet were found to be within 20% difference from the mean concentration for selenium. For mercury, on average 93% of samples were found to be within 20% of the mean concentration. Arsenic, zinc, and copper showed more variability, with the average number of samples within 20% of the mean concentration being 82%, 85%, and 74%, respectively. The most variable sample locations on the filet were found to be at the extreme anterior, posterior and ventral locations of the fish; these locations were also noted to be the most oily tissue. Overall, results suggest that a small tissue plug, typically collected near the dorsal fin, is representative of a whole filet, promoting non-lethal options for fish tissue sampling without compromising on quality.

4.18.P-Tu263 Characterizing Dissolved Organic Matter Sources and Dynamics in Biscayne Bay and Its Major Tributaries

David Hajiyev[1], Luis Bordin[1], Kassidy Troxell[2], Maria Guerra de Navarro[2], Daniel Omana[3] and Piero Gardinali[1] (1)Florida International University (FIU) Institute of Environment, (2)Florida International University, (3)Florida International University (FIU)

Biscayne Bay is a protected subtropical estuary in South Florida that supports diverse ecological communities and provides substantial environmental and economic value. In recent years, hydrologic alterations and nutrient enrichment have contributed to eutrophication leading to hypoxia, seagrass loss, and recurring fish kills, particularly within Northern Biscayne Bay (NBB). Although extensive monitoring efforts have documented these water quality impairments, key knowledge gaps remain in the sources, composition, and cycling of dissolved organic matter (DOM) within the bay and its tributaries. This study characterized DOM dynamics across NBB and its major tributaries, the Miami River, Little River, and Biscayne Canal, to better understand watershed inputs and in-bay biogeochemical processes, such as remineralization. Water samples were collected from 61 sites during the wet and dry season (n = 244). In situ water quality measurements, including fluorescent dissolved organic matter (FDOM), were obtained using a YSI EXO2 sonde, while laboratory analyses were conducted using a Horiba Aqualog spectrofluorometer. FDOM measurements from the EXO2 sensor were compared to laboratory fluorescence measurements (Excitation: 362 nm; Emission: 456 nm) to evaluate sensor performance. Full excitation-emission matrix (EEM) spectra (240-800 nm) were analyzed using Parallel Factor Analysis (PARAFAC) to identify distinct DOM components and examine relationships with nutrients and other

physicochemical parameters. FDOM concentrations exhibited strong spatial variability across the watershed, ranging from 1-100 Quinine Sulfate Units (QSU) within Biscayne Bay, 89-250 QSU in the Miami River, 88-145 QSU in the Little River, and 40-120 QSU in Biscayne Canal. Elevated fluorescence signals in tributaries relative to the bay suggest substantial terrestrial and anthropogenic organic matter inputs from urbanized watersheds. PARAFAC analysis further revealed relationships between FDOM, nutrient concentrations, and other physicochemical parameters, highlighting the influence of watershed inputs and in-bay biogeochemical processes on DOM composition across the study area. These findings demonstrate the value of integrating in situ fluorescence monitoring with advanced spectroscopic analyses to characterize watershed-derived organic matter and support water quality management in Biscayne Bay.

4.18.P-Tu264 Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) Quantification of Metal and Metalloids in Size-Fractioned Particulate Matter (PM) Near Metallurgic Industries

Marie-Pier Reid[1], Emmet Norris[1], Patrick Hayes[1] and Kevin Wilkinson[1] (1)University of Montreal (UdeM)

Metals and metalloids can often be found in airborne particulate matter (PM) near metallurgic industries. Higher concentrations of specific elements are a concern for the local populations considering the possible toxicity of these elements. The smaller size fractions, especially fine (< 2.5µm) and ultrafine (< 0.1µm) particles, can be more problematic since they can penetrate deeper in the respiratory system, which justifies the analysis of the elementary composition of size-fractioned PM. Chemical and physical analysis of PM also helps to identify emission sources, a necessary step to enable management of these sources in the long term.

Airborne particles can be separated by their size during sampling with a cascade impactor like the Micro-Orifice Uniform Deposit Impactor (MOUDI). The model of the MOUDI used in this work, the MOUDI-II 120R, can divide the particles in ten size intervals ranging from 56nm to 18µm, which can then be analyzed separately by inductively coupled plasma-mass spectrometry (ICP-MS). The goal of this work is to quantify a variety of elements (Al, Ag, As, Ba, Bi, Ca, Cd, Cr, Cu, Fe, In, K, Mg, Mo, Na, Ni, Pb, Sb, Se, Si, Sn, Sr, Te, Ti, Zn) in size-fractioned PM sampled during the summer of 2025.

Detecting and quantifying elements of interest in size fractioned PM over multiple sampling periods allows us to use positive matrix factorization (PMF) for source apportionment, identifying which modeled sources contribute to fractions of observed elemental concentrations. Using wind data also helps distinguish emissions coming from the industry and from residential areas. Information from PMF analysis benefits populations and industry, helping identify the emission sources and informing citizens about the air quality of their environment.

4.18.P-Tu265 Per- and Polyfluoroalkyl Substances (PFAS) Characterization of Synthetic Field Turf Components: Results and Lessons Learned

Stephanie Kukolich[1], Catalina Restrepo[1], Michael Peterson[1] and Kim Reynolds Reid[1] (1)Gradient

Charactarizing PFAS in synthetic turf components is often difficult because turf may contain a wide variety of other fluorine-bearing compounds, from inorganic fluorine (IF) in minerals to non-PFAS organofluorines. While PFAS testing of select target analytes in products has been well established, there are no standard

methods to determine the concentration of organic vs. inorganic fluorine in solid, heterogenous turf materials. We present the results and lessons learned from PFAS and non-specific fluorine testing in synthetic turf using a suite of analytical methods. Solid turf materials were measured via US Environmental Protection Agency (US EPA) Method 1633 for targeted PFAS analysis, as well as for total fluorine via combustion ion chromatography (TF via CIC) and IF via Pace Method 121,4500F-BC to calculate total organic fluorine (TOF). Some of the turf materials were also subjected to a synthetic precipitation leaching procedure (SPLP), followed by US EPA Method 1633 and adsorbable organic fluorine (AOF; US EPA Method 1621) testing to simulate the potential leaching of PFAS and organic fluorine out of the turf and into soil and groundwater from rainfall. Most samples were measured in duplicate, which enabled monitoring precision across the sample data. All PFAS and non-specific fluorine testing results were similar to or lower than background concentrations in soil and precipitation. We found, however, that all methods exhibited some degree of imprecision, potentially due to sample heterogeneity. In addition, TOF measurements in solid turf products have the potential for high bias because the leaching procedures used to measure IF may not account for insoluble minerals measured as part of the TF via CIC analysis. Since each method detects a different subset of fluorinated compounds, the analytical approach used must be considered carefully when evaluating products for regulatory compliance or potential human and environmental impacts, as differences in method scope can potentially limit data interpretation. Further, we encourage duplicate or triplicate analyses to evaluate reproducibility.

4.18.P-Tu266 Characterizing Bismuth Released From Municipal Wastewater Effluents

Christian Gagnon[1], Alexandre Chalifoux[1], Patrice Turcotte[1], Francois Gagne[1] and Shirley Anne Smyth[1] (1)Environment and Climate Change Canada (ECCC)

Various forms (including nanoparticulate) of bismuth after various uses enter urban wastewater and flow through municipal wastewater treatment plants (WWTPs). However, little is known about the effectiveness of treatment processes to remove these elements and the concentrations released in effluents to receiving waters. The main objective of this study was to investigate the fate and partitioning of bismuth released from various wastewater treatment processes. A secondary objective was to evaluate the released Bi in terms of concentrations and forms compared to the naturally-occurring Bi in surface waters. To monitor these elements in different WWTPs, various urban influents and effluents from simple aerated lagoons to advanced treatments were sampled in Canada. The results showed that the rates of Bi removal by treatment processes are high (> 90%), but effluent discharges significantly contribute (up to 300 ng/L) to the enrichment in Bi, mainly colloidal and particulate, in effluent-receiving surface waters. Bi was mainly present in the particulate fraction (>0.45µm), representing 79 ± 13% of the mass of Bi released. Further characterization of the released Bi was carried on their nanoparticle size distribution using Single particle-ICP technique. Typical results for municipal wastewater were that small nanoparticles fraction (< 25 nm) represented most of nano-sized particles for a concentration >0.4 ng Bi/L. Those significant sources of Bi, mainly as fine particles, potentially contribute to Bi enrichment of the receiving waters. The environmental risk of Bi associated with the nano-scale forms remains unknown.

4.18.P-Tu267 Spatiotemporal Trend Analysis of Heavy Metals in California Watersheds

Randi Barton[1] and Bushra Khan[1] (1)University of California Davis (UC Davis)

With increasing anthropogenic use of heavy metals, elevated concentrations are expected to be deposited in

surface sediments in freshwater streams. While some metals, such as copper and zinc, are essential nutrients in trace quantities, they can be toxic at high concentrations. Under the Surface Water Ambient Monitoring Program (SWAMP), the Stream Pollution Trends Monitoring Program (SPoT) was initiated in 2008 to determine long-term statewide trends of contaminants, including metals, and aquatic toxicity in California streams. Cadmium, copper, lead, nickel, and zinc have been monitored statewide across 90 sites annually. These metals are used in numerous industrial, residential, and agricultural applications. Here we present statewide, regional, and site-specific sediment metal trends in California between 2008-2024, with an emphasis on land use relationships. On a statewide scale, lead, zinc, and nickel have significant relationships with urban and agricultural land uses. Increasing site-specific trends were identified for cadmium, lead, zinc, and nickel, while most sites have stable or decreasing copper trends. Region-specific relationships were identified for both urban and agricultural land uses indicating potential sources and pathways of metal contamination in freshwater habitats. These trends at different spatial scales inform future monitoring strategies while supporting site prioritization for the program and evaluation of regulation effectiveness.

4.18.P-Tu268 Occurrence of 122 Pharmaceuticals and Personal Care Products (PPCPs) Including 38 Antimicrobial Agents in Japanese Rivers

Norihiro Kobayashi[1] and Yuko Tsuchiya[2] (1)National Institute of Health Sciences (NIHS), (2)National Institute of Health Sciences

TTo clarify the risk levels of pharmaceuticals and personal care products (PPCPs) including antimicrobial agents in Japan’s aquatic environment, environmental monitoring was conducted to assess emissions from sources of antimicrobial agents and their dispersion in river water. We selected 122 PPCPs, including 38 antimicrobial agents with high domestic shipment volumes, as target substances. Environmental monitoring was conducted in 12 rivers from October 2025 to August 2026. We selected 122 human and veterinary pharmaceuticals, including 38 antimicrobials with high domestic shipment volumes, as target substances. Measurements were conducted in 12 rivers from October 2025 to August 2026. Six internal standards were added to 500 mL of water samples, which were then concentrated to 0.5 mL via solid-phase extraction and analyzed by LC/MS/MS. The LC/MS/MS analytical conditions followed those used in our previous studies. A total of 81 PPCPs, including 17 antimicrobial agents, were detected in the river water samples. The highest concentration of an antimicrobial was clarithromycin (560 ng/L), detected in the Arakawa River. This sampling site is located downstream from a wastewater treatment plant. Concentrations of antimicrobials and PPCPs at other sampling sites were comparable to or lower than those in our previous studies, suggesting that the impact of discharge sources was not particularly significant. By integrating the data obtained in this study with ecotoxicity testing data, it is possible to identify antimicrobials that require priority monitoring and to obtain information that will serve as a foundation for future risk assessments.

Disclaimer/Disclosure: This work was funded by the Environment Research and Technology Development Fund (ERTDF) under Grant Number SII-12-3(2).

4.18.P-Tu269 Sterols, Stanols and Lerma River, Mexico State, Mexico

Elsa Norena-Barroso[1], Gabriela Rodriguez Fuentes[1], Anne-Laure Bussy[2] and Aquetzali Reynoso-Martínez[3] (1)National Autonomous University of Mexico (UNAM), (2)Metropolitan Autonomous University (UAM),

(3)Metropolitan Autonomous University

Stanol and sterol concentrations in sediments may be used for the identification of domestic discharges in rivers, as some of them are found in feces while others are part of vegetal tissues. For their demonstrations, authors usually utilize concentrations, but also percentages of total analyzed stanols and sterols. The third indicator is a group of relations between molecule concentrations (ratios). This study compared the three methods via the Lerma River, Mexico State, which receives numerous discharges, after its beginning in a relatively unpolluted lake and a short section through an agricultural neighborhood. Collected samples were freeze dried and sieved, before molecule extraction, concentration and derivatization, in order to be analyzed with GC-MS (SIM mode). Studied molecules were: C27-cholesterol and its metabolites (cholestanol, coprostanol and epicoprostanol) on one hand, four vegetal sterols (C29-stigmasterol, C29-B-sitosterol, C29-B-sitostanol and C28-campesterol) on the other hand. The principal components analysis (PCA) of concentrations did not completely ordinate sampling sites between with and without domestic discharge. Worse, it formed a group mixing both types of sites. However, the first axis showed an approximative evolution of sites following total concentration and a Pearson correlation-based cluster distinguished the 2 groups of molecules: cholesterol and its metabolites and the vegetal molecules. The same analysis for percentages did completely ordinate sampling sites between with and without domestic discharge. Besides, the simple percentage of both groups (C27 and C28+C29) was enough to clearly indicate domestic discharge existence. Some of the relations between concentrations were highly correlated (Pearson coefficient up to 0.959), as most of these were elaborated to expose domestic discharges. If the associated PCA did not show a perfect dichotomy, it made smaller groups and isolated special sites as Ameyalco River, the farm entry or the field. Thus, each of the three methods brought different kind of information for a discussion. However, the ratios between compounds can provide detailed information for a deeper discussion.

4.18.P-Tu270 Evaluating Global-Scale Emissions, Transport, and Deposition of Cyclic Volatile Methylsiloxanes in Remote Areas

Jaeshin Kim[1] and Jingyun Ye[1] (1)Dow Chemical Company

Long-range transport potential (LRTP) assessments require environmental multimedia models to capture the multiple pathways by which chemicals reach remote regions in the absence of direct emissions. Here, we apply the Emissions Fractions Approach (EFA) to assess the LRTP of cyclic volatile methylsiloxanes (cVMS), extending the OECD Pov and LRTP Screening Tool by explicitly quantifying fractions of dispersion (ϕ1), transfer (ϕ2), and accumulation (ϕ3) in remote surface media relative to the recommended threshold values derived from persistent organic pollutants (POPs). Although these fractions are independent of emission rates, other model outputs (such as concentrations and mass fluxes that are strongly dependent on chemical emission rates) were also evaluated.

The model tested both realistic emission scenario for VMS and three fundamental cases representing 100% emission to air, water, or soil. Total cVMS emission rates were based on global estimation to ensure that predicted concentrations and mass fluxes were within realistic ranges. A sensitivity analysis was conducted to assess the influence of emission mode on LRTP outcomes. Owing to their high volatility and hydrophobicity, cVMS are predominantly distributed in the air compartment and can undergo long-range atmospheric transport, as indicated by dispersion fractions (ϕ1) exceeding the threshold values.

In contrast, under realistic emission scenarios, the fractions of transfer (ϕ2) and accumulation (ϕ3) are 1-2

orders of magnitude lower than the maximum values predicted across the three bounding emission modes and fall 2-4 and 3-6 orders of magnitude below their respective threshold values. These results indicate negligible deposition and accumulation in remote surface media. Overall, despite their potential for long-range atmospheric dispersion, the very low transfer and accumulation fractions indicate that VMS are unlikely to accumulate in remote environments.

4.18.P-Tu271 Per and Polyfluoroalkyl Substances (PFAS) Bound to Particulate Matter in Dust: Quantifying Airborne PFAS in Indoor Environments

Emily Blokland[1] and Amy Rand[1] (1)Carleton University

Per and polyfluoroalkyl substances (PFAS) can readily bind to particulate matter (PM) with a diameter of less than or equal to 10 micrometers. The smaller the diameter of particulate matter, the deeper these compounds can penetrate into the lungs, resulting in negative effects on the respiratory and cardiovascular systems. Despite the known health hazards, there is a lack of data surrounding PFAS concentrations within airborne dust in indoor environments. In addition, the extent of daily human inhalation exposure is unknown, especially in the context of newly built homes.

This project addresses this knowledge gap by quantifying airborne PFAS in newly built homes in the Ottawa region. We hypothesize that newly built homes contribute detectable levels of PFAS in indoor dust samples. To evaluate this, a Nano-MOUDI 11 Impactor was used to collect airborne PM and separate the samples into a variety of size fractions. To our knowledge, the use of this instrumentation provides a novel approach to separating particulate matter-bound PFAS in this context. Method development is underway, using solid phase extraction (SPE) to separate and concentrate the targeted PFAS present from the air filters. Following extraction, liquid chromatography coupled with mass spectrometry (LC-MS) is used to quantify the polyfluoroalkyl phosphate esters (PAPs) and ionic PFAS. In contrast, gas chromatography coupled with mass spectrometry (GC-MS) is used to measure the neutral PFAS present in the samples.

This project aims to characterize airborne PFAS contamination through dust samples within indoor environments in the Ottawa region. By addressing the knowledge gaps mentioned, the final data analyzed in this project can help support the refinement of future risk assessments and indoor air quality regulations in Canada. In addition, insights into ratios between legacy and short-chain PFAS can be analyzed to determine the prevalence of phased-out compounds in indoor environments.

4.18.P-Tu272 Temporal Comparisons of per- and Polyfluoroalkyl Substances (PFAS) in Sediments Collected From Urban Watersheds Across California

Bushra Khan[1] (1)University of California Davis (UC Davis)

The Stream Pollution Trends Monitoring program (SPoT) is a statewide program initiated in 2008 under the Surface Water Ambient Monitoring Program of the California State Water Resources Control Board. The program provides critical information about watershed health and identifies trends in sediment toxicity and contaminants in the context of land use across California. Per-and polyfluoroalkyl substances (PFAS) have been monitored since 2023 at 40 sites influenced by urban land use (USGS's National Land Cover Database categories 21, 22, 23 and 24). Given the ubiquity, high persistence, bioaccumulative potential, and toxicity of PFAS, determination of their spatiotemporal trends is essential to guide monitoring designs. A suite of 40 PFAS

including perfluoroalkyl carboxylic acids (PFCAs), perfluoroalkyl sulfonic acids (PFSAs), precursors and replacement PFAS, were measured in surface sediment samples. Total PFAS were calculated by summing reported concentrations of all 40 PFAS. Percent contributions to total PFAS at each site as well as detection frequencies across sites were calculated for individual compounds. Between 2023 and 2025, sites with highest PFAS sums as well as diversity belonged to Region 2 (San Francisco Bay), Region 4 (Los Angeles), and Region 9 (San Diego). When delineated at 5 km within the watershed, these sites reflect >50% urban land use ranging between 58 and 96%. The highest detection frequency across sites was observed for perfluorooctanesulfonic acid (PFOS, ranging 81-90% across three years). Sites with higher sums were often dominated by PFOS. Additionally, long-chain PFCAs (≥ C8) were reported at more sites than short-chain (< C8). Perfluorooctanesulfonamide (PFOSA) and perfluorooctane sulfonamido acetic acids (FOSAAs) were also found at several sites across three years. Despite these similarities, notable differences were observed at some urban sites. Ranges of sum PFAS across sites were 0-14 ng/g, 0-40 ng/g, and 0-7 ng/g dry sediment in 2023, 2024, and 2025, respectively, representing temporal shifts in PFAS concentrations and diversity. Sediment contaminant profiles across California watersheds reflect complexity of PFAS mixtures that need to be further monitored. Ongoing monitoring is aimed at identification of regional and statewide temporal trends.

4.18.P-Tu273 A Retrospective Assessment and Characterization of per- and Polyfluoroalkyl Substances (PFASs) in the Laurentian Great Lakes

Andrea Pugh[1], Erik Davenport[1], W. Edward Johnson[1] and Michael Edwards[1] (1)NOAA

Per- and polyfluoroalkyl substances (PFASs) represents a group of synthetic fluorine-containing compounds, with over 12,000 variations in existence, used in consumer and industrial applications related to surface protection/coatings, fire-fighting aqueous film-forming foams (AFFF), insecticides, and commercial polymer manufacturing. PFAS compounds are remarkably persistent, and resist biodegradation based on their physicochemical properties and stable structures, thus allowing the persistence of these contaminants in aquatic environment for extended periods. Consequently, PFAS have become ubiquitous environmental contaminants that bioaccumulate across aquatic food webs, impacting both lower- and upper-trophic-level organisms, as well as humans. Using tissue contaminant data collected from Great Lakes dreissenid mussels (zebra/quagga; Dreissena spp.) between 2013 and 2018, we conducted a retrospective (post-hoc) study to characterize the occurrence, magnitude, and spatial distribution of PFAS across the Great Lakes basin. The findings revealed, PFAS compounds were mainly detected as complex mixtures in mussels at one or more sampling location basin-wide, with elevated PFAS levels consistently detected in mussels from river, tributary, and harbor sites. Our results further revealed patterns in elevated mussel PFAS contaminant levels closely matched sites sampled adjacent to developed/urban land-use gradients and riverine systems, with larger population densities in Lakes Michigan, Erie, Ontario, and the Detroit and Niagara River connecting channels. PFAS composition was highest in mussels sampled from non-WWTP sites, relative to other discharge-types, confirming the importance of non-point and diffuse sources as significant environmental pathways for PFAS compounds detected within the Great Lakes. The findings will help in contextualizing the relationship between detected PFAS compounds and their environmental pathways, discharge-types, land-use gradients, as well as their likely “sinks” and “hot spots” across the Great Lakes Basin. These insights provide a roadmap for environmental managers to prioritize PFAS compounds to be monitored, thus making the most efficient use of resources and funds, while identifying appropriate management actions that can be used to support targeted strategies and measures in reducing and abating the continued occurrence of these persistent legacy and emerging chemicals of mutual concern (CMCs)

in the Great Lakes Basin.

4.18.P-Tu274 Characterizing the Interaction of Renewable Diesel With Groundwater

Kaylee Onucki[1], Nicholas Utting[2] and Shira Joudan[3] (1)University of Alberta, Natural Resources Canada-CanmetENERGY Devon, (2)Natural Resources Canada-CanmetENERGY Devon, (3)University of Alberta

The petroleum-diesel fuel substitutes biodiesel and renewable diesel are expected to increase in use due to the drive to lower carbon emissions. These fuel substitutes are made from renewable feedstocks such as plants and cooking oils. Renewable diesel is an appealing substitute due to its ability to be a direct replacement without the need for engine modifications. To be qualified as a replacement fuel, renewable diesel's physical and chemical properties must fall within the same range of properties as conventional fuels (e.g. viscosity, flashpoint, density, sulfur content). However, the precise chemical mixture may be different compared to petroleum diesel based upon biomass sources and production pathways. This study aims to fill knowledge gaps around the fate of these emerging fuels if they are accidentally released by a pipeline or underground storage tank and subsequently encounter groundwater as they migrate beyond the leakage location. A simulated pipeline leakage experiment, which involved injecting renewable diesel upstream into a groundwater flow simulation tank, was operated for five months. Effluent samples from the tanks were collected at intervals for chemical analyses including total organic carbon (TOC), benzene, toluene, ethylbenzene, and xylene (BTEX), polyaromatic hydrocarbons (PAHs), and alkylated polyaromatic hydrocarbon (APAHs). Analytical data suggest that up to 80 wt% of dissolved TOC mass that remains is unidentified in the renewable diesel-water effluent. Comprehensive two-dimensional gas chromatography – flame ionization detection reported variability in chemical composition across renewable diesels. A simplified water mixing experiment of renewable diesels identified that the water-soluble component was composed of phenols and alkanes. Further analysis of water extracts using gas chromatography – mass spectrometry is ongoing for quantitative analysis. This targeted analysis will be applied to a follow up tank study again involving an additional renewable diesel, with a different chemical composition, to compare the behavior of the first renewable diesel with a second one.

4.18.P-Tu275 Development and Calibration of a Novel Passive Sampler for the Detection of per- and Polyfluoroalkyl Substances in Indoor Air

Melissa Woodward[1], Jitka Becanova[1], Simon Vojta[1], Alexandra Provasnik[1] and Rainer Lohmann[1] (1)University of Rhode Island

Per- and polyfluoroalkyl substances (PFAS) are contaminants of emerging concern whose widespread presence, persistence, and health risks highlight the need for practical tools to measure them in the atmosphere, where current methods are often unsuitable for capturing the full scope of PFAS or are impractical to deploy. Here, we take a diffusive tube combined with a high-capacity sorbent and demonstrate its use as a reliable passive sampler for quantifying both ionic and volatile, neutral PFAS in the atmosphere. Atmospheric concentrations obtained from passive samplers were consistent with atmospheric concentrations determined by active sampling for both ionic and volatile, neutral PFAS, with a regression slope of 0.835 that was not significantly different than 1, representing near-perfect agreement. Sampling rates increased with both temperature and wind speed. For example, the modelled sampling rate for 6:2 fluorotelomer alcohol (FTOH) was 0.095 m^3/day at 25 °C with no wind, 0.098 m^3/day at 30 °C with no wind, and 0.099 m^3/day at 25 °C with 0.25 m/s wind. Deployments in contrasting indoor environments (homes in Alaska and the Faroe Islands, and university spaces in Arizona and

Rhode Island) demonstrated the ubiquity of 6:2 FTOH, with concentrations ranging from 0.5 ng/m³ to 22.1 ng/m³. Based on this study and demonstrated application, the sorbent filled diffusive tube is a promising tool for measuring a wide scope of atmospheric PFAS in various environmental conditions.

4.18.P-Tu276 Characterization and Considerations of Atmospheric Deposition as an Aquatic Exposure Pathway

Stephanie Kennedy[1], Chloe Fender[1], Jennifer Bare[1], Julie Panko[1] and Deborah Proctor[1] (1)ToxStrategies

Decades of research and regulatory efforts have resulted in a robust understanding of primary exposure pathways to aquatic environments. Some pathways, however, remain understudied and unquantified. These understudied pathways include airborne dispersion, deposition, and transport mechanisms that are harder to measure, such as air deposition to aquatic systems or transport from groundwater into surface water. Currently, these pathways are assumed to contribute a relatively small proportion of the total pollutants to ecosystems. However, these understudied pathways also pose a challenge to quantify, resulting in uncertainty around whether they truly are minor pathways, or simply harder to measure or predict. To extend the understanding of pollution sources and exposure pathways, we aimed to: 1.) survey the current knowledge on atmospheric deposition as an aquatic environment exposure pathway; and 2.) describe key findings, information gaps, and considerations for future work.

Several anthropogenic and non-anthropogenic air contaminant sources (e.g., organics, metals, inorganics) occur in the particulate and vapor phases that may contribute to this understudied pathway. Most research for this pathway focuses on monitoring air quality parameters, characterizing particulate matter and pollutants in ambient air, or testing the effects of air pollution constituents in laboratory-based toxicity tests. A targeted review indicates that this exposure pathway's relative contribution to pollutant concentrations and their toxic effects in aquatic organisms has not been fully evaluated. Few studies have confidently quantified the amount of particulate matter or other airborne pollutant deposited into aquatic systems, or determined if the constituents are bioavailable, both of which are important considerations for exposure characterization. Current biogeochemistry research offers atmospheric aerosol deposition and metal leaching models for oceans, but these typically focus on global scales rather than the local or regional approach needed for a conceptual site model appropriate for risk assessment. To fully evaluate atmospheric deposition risk and inform regulatory action, additional research is needed to characterize and quantify this understudied exposure pathway.

4.18.P-Tu278 The STAMP Egg Collection at the NIST Biorepository

Jennifer Hoguet[1] and Rebecca Pugh[1] (1)National Institute of Standards and Technology (NIST)

Seabird eggs have demonstrated a valuable role in the monitoring of environmental pollutants. As such, in 1999, the Seabird Tissue Archival and Monitoring Project (STAMP) was established as a long-term collaboration between the National Institute of Standards and Technology (NIST) and a multitude of local, state, and federal agencies to monitor pollutant trends in the Alaskan marine environment. To do so, standardized protocols were developed and implemented for the systematic collection and processing of seabird eggs. Resultant egg contents and eggshell samples are archived at the NIST Biorepository in Charleston, SC. The goals are to minimize contamination and ensure long-term stability, both key for optimal real-time and

retrospective analyses. Since STAMP's inception in Alaska, 1903 eggs from target species (e.g., Uria spp., Larus spp.) spanning 45 colonies have been collected, the majority of which have been utilized for environmental monitoring studies.

In 2010, the 111th U.S. Congress tasked NIST with expanding its capabilities to the Pacific region. As a result, STAMP was extended to the Pacific Islands with target species including Laysan albatross (Phoebastria immutabilis), black-footed albatross (P. nigripes), wedge-tailed shearwater (Ardenna pacifica), sooty tern (Onychoprion fuscatus), gray-backed tern (Sterna lunata), masked booby (Sula dactylatra), and brown booby (S. leucogaster). To date, 935 eggs spanning 28 colonies have been collected and archived. In contrast to the Alaskan collection, the Pacific Island collection has been underutilized but remains a valuable resource for environmental monitoring. STAMP sample usage is highly encouraged and may be requested through an established tissue access policy.

4.18.P-Tu279 River Biofilms As Monitors of Metal Bioavailability for a Mine Pit Dewatering Project in Gaspésie, Qc

Sarah Bérubé[1], Isabelle Lavoie[1] and Claude Fortin[1] (1)National Institute for Scientific Research (INRS)

Mining activities can increase metal concentrations in ecosystems, particularly in aquatic environments located near mining sites. In the context of the dewatering of a copper mine pit in Gaspésie, Qc, pumping pit water into nearby watercourses represents an environmental concern due to the potential alteration of metal bioavailability and toxicity for aquatic organisms by the introduction of metal contaminants into streams. This project aims to develop a biomonitoring tool to determine metal bioavailability using algal biofilms during a dewatering scenario. This will also contribute to assessing associated risks along a concentration gradient between impacted and reference sites. First, a baseline condition prior to dewatering was established, and then microcosm experiments were conducted to simulate the dewatering process through the discharge of pit water into nearby watercourses. The results will contribute to a better understanding of metal exposure dynamics in aquatic ecosystems affected by mining activities and will help support the development of dewatering strategies using a biomonitoring tool.

4.18.P-Tu280 Assessment of the Usefulness of Biofilms and an Aquatic Invertebrate (Hyalella azteca) as a Biomonitor for Metal Contamination

Agnès Le Gal[1], Claude Fortin[2] and Maikel Rosabal[3] (1)Institut national de la recherche scientifique, (2)National Institute for Scientific Research (INRS), (3)University of Quebec in Montreal (UQAM)

Mining activities, which are widespread throughout Quebec, represent a major source of polymetallic contamination in aquatic ecosystems. To support the mining sector in adopting more sustainable practices, government agencies require robust biomonitoring tools to assess its environmental footprint. Although the use of biomonitor organisms has already demonstrated considerable potential, little is known about their usefulness in polymetallic-contaminated environments. This study aims to evaluate the suitability of biofilms and the aquatic invertebrate Hyalella azteca as biomonitors in aquatic mining-impacted ecosystems. To achieve this objective, ten lakes located around the Horne Smelter in Rouyn-Noranda (Canada), representing a contamination gradient, were sampled. The relationship between metal concentrations measured in environmental compartments (water and sediments) and those accumulated in biomonitors was examined to

assess their ability to reflect environmental conditions. Metal behaviour was also investigated through the assessment of metal speciation and bioavailability. These results were subsequently related to environmental factors, including pH, dissolved organic carbon, and major anions and cations, to improve our understanding of the processes controlling metal bioaccumulation and ultimately strengthen the use of these organisms in biomonitoring programs. Preliminary results confirmed the contamination gradient across lakes for several elements, particularly As, Cd, Co, and Cu. Partial ultrafiltration revealed marked differences in metal speciation, with Cu, Pb, and La occurring predominantly in complexed forms, suggesting an important influence of dissolved organic matter on their potential bioavailability. Relationships between environmental concentrations and metal accumulation in biofilms varied substantially among metals, highlighting metal-specific differences in bioavailability and bioaccumulation processes. In several cases, free-ion concentrations did not improve the prediction of bioavailability in our conditions. These findings highlight the importance of considering metal speciation and environmental factors when assessing metal bioavailability and support the development of integrated biomonitoring approaches combining environmental chemistry and biological responses in mining-impacted aquatic ecosystems.

4.18.P-Tu282 Beyond Single-Endpoint Ecotoxicity Screening: Domain-Aware Computational Assessment of Transformation Products in Advanced Oxidation Water Treatment

Yunseo Lee[1], Minju Kim[1], Eunbyeol Kim[1], Yejee Jeon[1] and Sungik Yang[1] (1)Kyung Hee University

This presentation critically examines the computational toxicity assessment of transformation products (TPs) generated during photocatalytic and advanced oxidation processes (AOPs). Although AOPs are widely investigated for the removal of pharmaceuticals, pesticides, and other micropollutants, parent-compound disappearance alone does not necessarily demonstrate detoxification. TPs may retain pharmacophoric substructures, acquire reactive toxicophores, or persist as components of bioactive mixtures. When authentic standards and measured toxicity data are unavailable, TP hazard is commonly evaluated using QSAR-based screening tools, most prominently ECOSAR and, less frequently, TEST. However, such assessments are often based on a limited number of predicted acute endpoints, such as Daphnia LC50, without systematic reporting of structural identification confidence, applicability domain (AD), or prediction uncertainty.

Recent photocatalytic toxicity-reduction studies suggests that computational TP assessment is frequently used as supportive evidence for detoxification, whereas explicit discussion of AD, uncertainty, read-across rationale, and measured-to-predicted comparison remains relatively limited. This does not invalidate the use of QSAR tools, but it highlights the need for clearer reliability qualification. This issue is particularly relevant because AOP-generated TPs can be challenging targets for conventional QSAR and read-across approaches. Novel oxidized scaffolds, transient intermediates, reactive electrophiles, radical-derived products, and HRMS-related structural ambiguity may place compounds near or outside structural, descriptor, mechanistic, or endpoint domains, while complicating analogue selection.

To address these limitations, we propose a tiered, domain-aware workflow that integrates multi-tool, multi-endpoint consensus prediction; formal AD and uncertainty evaluation; toxicophore profiling; and screening-grade transformation-series read-across as complementary but confidence-limited evidence layers. The proposed workflow does not treat computational predictions as definitive evidence of detoxification, but as a transparent screening framework for identifying TPs and transformation pathways that warrant further experimental evaluation.

4.18.P-Tu283 Environment and Climate Change Canada's Integrated Chemical Mixtures Project in the Canadian Environment

Sylvie Poirier[1], Geneviève Tardif[1], Marie-Claude Sauvé[1], Alicia Berthiaume[1], Zhen Cheng[1], Rebecca L. Dalton[1], Tom Harner[2], Mark Hewitt[2], Robert Letcher[2], Stacey Robinson[2] and Tristan Smythe[2] (1)Environment and Climate Change Canada, (2)Environment and Climate Change Canada (ECCC)

The Integrated Chemical Mixtures Project (ICMP) was launched by Environment and Climate Change Canada in 2023 to support implementation of the right to a healthy environment under the Canadian Environmental Protection Act, 1999 (CEPA). The ICMP aims to develop an approach to increase understanding of real-world chemical mixtures that may be present in the environment, beginning in two regions in Canada.
The four-year ICMP consists of two regional case studies designed to investigate chemical mixtures across multiple environmental media (air, water, sediment, soil and wildlife) in Brantford and Sarnia, Ontario, Canada. More than 20 research projects are studying chemical mixtures through integrated scientific approaches and across diverse fields of expertise, including chemical analysis (targeted and non-targeted analyses, environmental fate modelling) and ecotoxicological analysis (effect-based analysis and new approach methodologies (NAMs)). Their objective is to determine whether chemical mixtures are having regional impacts. If adverse effects are observed, further investigation of the cause of the effects and the associated pollution source(s), and possible solutions (if applicable), would be considered. Partnerships are in place to support integration and collaboration across the project, including Government of Canada researchers, regulators, academic researchers, provincial and municipal governments as well as First Nations and local stakeholders. This holistic approach may be applied to other regions in Canada. As we are finalizing the project, participants are currently determining how best to integrate the large datasets generated and address key research questions about potential impacts of chemical mixtures in these regions.

General: Chemistry and Exposure Assessment

4.18.V-01 Green Acid-Base Indicator From Indigenous Non-Food Plant Leaves in South-South Nigeria

Prof. Chioma Blaise Chikere[1], Hilary Chizaram Chikere[2], Dr. Chinenye Amarachukwu Igboamalu[3] and Dr. Princely Enyinnaya Nwojo[3] (1)1. University of Port Harcourt (UniPort), Nigeria. 2. University of South Africa (Unisa), (2)Charles Dale Memorial International School (CDMIS), Port Harcourt, Rivers State, (3)University of Port Harcourt (UniPort)

Sustainable and green chemistry is based on the initiatives and innovations that reduce waste, save energy and are environmentally friendly. This study investigated the efficiency of ethanolic leaf extract of Acalypha wilkesiana (LEAW) as an eco-friendly acid-base indicator which could serve as an alternative in Low- and Middle-Income economies where reagents for basic science practical could be expensive to acquire. Ethanolic extract of Acalypha wilkesiana fresh leaves was obtained using absolute ethanol in cold extraction for about 72 hours. It was filtered and the filtrate concentrated by allowing it to stand for 86 hours. The effectiveness of the extract as an acid-base indicator was compared with methyl orange (synthetic indicator) via titration between different acid-base combination (strong and weak). The measured pH values of methyl orange, phenolphthalein and LEAW were respectively 6.87, 4.65 and 6.97. The results obtained demonstrated that the extract had a very close range of pH with distilled water. The extract also exhibited different distinct colours at different pH range.

LEAW was observed to be a highly sensitive, eco-friendly, and acid-base indicator that is slight yellow in base and colourless in acid and could be a viable alternative for basic chemistry acid-base titrations especially in resource-limited settings.

4.18.V-02 Ecotoxicological Evaluation of Vancomycin Using Acute Toxicity and Cytogenetic Assays

Elizabeth Omotola[1], Bettina Genthe[2], Luyanda Ndlela[3] and Olatunde Olatunji[1] (1)University of KwaZulu-Natal (UKZN), (2)Independent Research, (3)Council for Scientific and Industrial Research

The growing prevalence of antimicrobial resistance has increased the global reliance on last-line antibiotics like vancomycin, raising concerns regarding environmental discharge and potential ecological effects. Therefore, the present study evaluates the ecotoxicological impacts of vancomycin using bioassays involving Daphnia magna and Allium cepa.

Freshwater was simulated using standard concentrated salt solutions according to the OECD guidelines for the testing of chemicals, Test number 202. Four replicate analyses were conducted for the analyte test solutions, with five daphnids placed in each well and exposed for 24 and 48 hours. After the exposure period had lapsed, the mortality or survival rate was recorded.
Allium cepa specimens were grown in triplicate at room temperature for two days in tap water after scraping the primordia at the bottom of the specimen with a sterile surgical blade to remove existing roots. After this period, the length of each root was recorded before exposure to 10 and 100 vancomycin test solutions for another two days. The roots were cut 3 cm from the tip after the exposure and placed in Carnoy's fixative for microscopic analysis.

Acute toxicity testing (24 and 48 hours) using Daphnia magna revealed 30% mortality across 10 and 100 ppb of vancomycin, preventing the calculation of the lethal concentration (LC50) value, which revealed low acute toxicity. Similarly, the Allium cepa root tip bioassay was conducted at the same concentrations of vancomycin used in the Daphnia magna assay. Root growth ratios (post-exposure: pre-exposure) were 2.23 ± 0.20 (control), 2.27 ± 1.00 (10 ppb), and 2.49 ± 0.57 (100 ppb). Analysis of variance (ANOVA) showed no significant differences among treatments ($p > 0.05$), indicating no observable phytotoxic effects on root elongation.

Nevertheless, microscopic examination of root tip cells indicated abnormalities (irregular prophase) at the cellular level, with no aberrations in the control treatment. This result indicates potential sub-lethal cytogenetic impacts not captured by root tip growth metrics alone. These findings reveal a disparity between cellular-level and organism-level responses, suggesting that vancomycin may still pose subtle biological risks despite its low acute toxicity.

Overall, these findings suggest that vancomycin may pose sub-lethal cytogenetic risks despite low acute toxicity, warranting further chronic exposure studies and environmental monitoring.

Innovative Mass Spectral and Chromatographic Analyses Applied to Ecotoxicology and Environmental Monitoring

4.19.T-01 Environmental Fate of Gadolinium-Based Contrast Agents: Solar Radiation Induced Transformation Products

Aissatou Y Sow[1], Huy Dang[2] and Claude Fortin[1] (1)Institut national de la recherche scientifique, Centre Eau Terre Environnement, Québec (QC), Canada, (2)School of the Environment and Chemistry Department, Trent University, Peterborough (ON), Canada

Gadolinium-based contrast agents (GBCAs) are widely used in medical imaging and are increasingly being detected in surface waters. In addition to the known forms of GBCAs, studies have reported the presence of other gadolinium-containing species of anthropogenic origin. This raises questions regarding the environmental fate of GBCAs and their degradation products. In the first part of this study, we examined the potential role of photodegradation in the formation of unknown compounds. Upon release into the environment, GBCAs are naturally exposed to solar radiation; however, limited information is available regarding their photochemical stability and degradation pathways. Two GBCAs, Gd-DTPA and Gd-BT-DO3A, were exposed to artificial solar radiation in ultrapure water and in river water. Aliquots of the irradiated solutions were collected at various time intervals and analyzed by direct infusion high-resolution mass spectrometry. Mass spectra were processed to identify gadolinium-containing species and assign molecular formulas based on accurate mass measurements and isotopic pattern matching. This approach enabled the identification of three photodegradation products and three impurities/derivatives of Gd-DTPA, as well as one degradation product of Gd-BT-DO3A. In the second part of the study, we investigated the potential role of dissolved organic matter in the formation of unknown gadolinium species. Dissolved organic matter is a key component influencing the environmental fate of organic contaminants through processes such as complexation. We incubated Gd-DTPA and Gd-BT-DO3A in matrices containing four different sources of dissolved organic matter. The resulting samples were analyzed using ion chromatography coupled with inductively coupled plasma mass spectrometry (IC-ICP-MS). Data analysis is currently ongoing. Results from the photodegradation experiments indicate that GBCAs are susceptible to photochemical transformation, potentially leading to the formation of previously unidentified gadolinium-containing compounds. Final results regarding the role of dissolved organic matter in the formation of these species will be presented.

4.19.T-02 Assessing Community Exposure to Persistent Mobile Toxic Chemicals in Rural Pennsylvania Drinking Water

Elizabeth Smith[1] and Carrie McDonough[1] (1)Carnegie Mellon University

There have been numerous reports of water and sediment contamination resulting from hydraulic fracturing. Fluids used in hydraulic fracturing contain persistent, mobile, toxic chemicals (PMTs) that could contaminate nearby drinking water sources. However, current methods for drinking water analysis typically select for volatile and semi-volatile compounds, or isolate hydrophobic contaminants, and many PMTs are overlooked. PMTs missed by these methods include quaternary ammonium compounds (QACs), alkyl phenol ethoxylates (APEOs), and ultra-short and short chain per/polyfluoroalkyl substances (PFASs). The objective of this study is to develop a sensitive method for analyzing mixtures of these PMTs at trace levels in drinking water using liquid chromatography with quadrupole-time-of-flight mass spectrometry (LC-QTOF-MS) for targeted

quantitation and simultaneous identification of novel PMTs. APEOs with an ethoxylate chain of 2 or greater and three classes of QACs – benzalkonium chlorides (BACs), didecyl dimethyl ammonium chlorides (DDACs), alkyl trimethyl ammonium compounds (ATMACs) – have been separated effectively on a Poroshell C18 column with aqueous 0.1% formic acid and neutral acetonitrile and detected using positive electrospray ionization (ESI). Octylphenol, nonylphenol, and ultra-short/short-chain PFASs were observed separated on an Ultra IBD column in 0.1% aqueous acetic acid and 90/10 ACN/water and detected using negative ESI. We will compare both dilute and shoot and liquid-liquid extraction sample preparation techniques using fortified water samples. This method will then be applied to the analysis of water samples from several communities at carrying distances from fracking activity in rural areas of Pennsylvania to compare PMT profiles between private wells vs. municipal water and distance from hydraulic fracturing sites. Results will allow for the assessment of community exposure in a fast, rugged manner for PMTs that are overlooked by traditional methods.

4.19.T-03 Characterizing Quaternary Ammonium Compounds With LC-QTOF HRMS: From Quantification to Transformation Products

Megumi Shimizu[1] and Kendra Adams[1] (1)SCIEX

Quaternary ammonium compounds (QACs) are widely used as disinfectants and surfactants, with increasing concern regarding their environmental persistence, transformation, and potential biological impacts. Sensitive and selective analytical approaches are therefore required to support their monitoring across complex environmental matrices. In this study, high-resolution mass spectrometry (HRMS) workflows were developed for both targeted and non-targeted characterization of QACs using LC-QTOF-HRMS.
The approach enables the identification of benzylalkyldimethyl and dialkyldimethyl ammonium homologues based on accurate-mass precursor ions and diagnostic MS/MS fragmentation patterns. Data-independent acquisition (DIA) enhances confidence in structural elucidation and supports the detection of both known and previously unreported QAC species without reliance on comprehensive analytical standards.
Application of this approach to environmental samples demonstrates robust analytical performance and broad chemical coverage, enabling improved characterization of QAC occurrence and distribution. This HRMS-based workflow provides a flexible and comprehensive strategy for investigating QAC presence and transformation in environmental systems, supporting ongoing efforts to better assess their fate and potential ecological impact.

4.19.T-04 FMS2Lib: An MS/MS Spectral Library of 35,000 Fluorinated Compounds for Machine-Learning-Assisted Nontargeted Analysis

Tao Yang[1], Xiaoyun Wang[1] and Hui Peng[1] (1)University of Toronto

Per- and polyfluoroalkyl substances (PFAS) have raised global concern because of their extreme environmental persistence. More than 14,000 PFAS have been manufactured, yet less than 10% of the fluorine mass balance in the environment can be explained by currently detected PFAS. This gap is largely driven by the extensive chemical diversity of fluorinated compounds, which exceeds the capacity of current nontargeted analysis approaches that remain focused mainly on traditional fluorinated compound classes. To address this challenge, we developed FMS2Lib, an experimental MS/MS spectral library comprising approximately 35,000 fluorinated compounds containing one to four fluorine atoms. FMS2Lib reveals novel and frequently occurring MS/MS

fragmentation chemistry of fluorinated compounds, including long-distance rearrangement reactions. To predict the molecular formulas and chemical structures of fluorinated compounds from MS/MS spectra, we first benchmarked existing models and then retrained the best-performing baseline models using FMS2Lib. After retraining, prediction accuracies improved from 0.38–0.81 to 0.91–0.98 for molecular formula prediction and from 0.49–0.55 to 0.74–0.77 for structure prediction, across compounds containing different numbers of fluorine atoms. Overall, FMS2Lib provides a high-quality, machine-learning-ready, and open resource for the nontargeted analysis of low-fluorinated PFAS in the environment, offering an important complement to existing methods.

4.19.T-05 Characterizing the Complex PFAS Signature in Fluoropolymer Ionomer Leachate

Cassandra Brinovcar[1], Amila De Silva[1] and Jeremy Gauthier[2] (1)Environment and Climate Change Canada (ECCC), (2)University of Guelph

Fluorinated ionomers are a subgroup of fluoropolymers that are copolymers of tetrafluoroethene and a perfluorinated vinyl ether monomer that possesses an ionic moiety such as a sulfonic or carboxylic acid. These are considered specialty polymers synthesized for applications that require an ionic quality. Fluorinated ionomers have been used in ion exchange membranes in electrochemical cells. Our objective in this research is to characterize leachable substances from a solid fluorinated sulfonic acid ionomer using ultra high-resolution mass spectrometry and non-targeted analysis. The polymer has a fully perfluorinated carbon backbone with repeating tetrafluoroethane units and has side chains consisting of perfluoropolyether sulfonic acids. Specifically, we obtained samples of 1,1,2,2-Tetrafluoro-2-[1,2,2-trifluoro-1 (trifluoromethyl)-2-[(1,2,2-trifluorovinyl)oxy] ethoxy]-ethanesulfonic acid polymer with tetrafluoroethylene (CAS 31175-20-9), which varied by manufacturer and lot number. Two of the samples were in powder form and one was a 2 mm pellet size. The polymer was subsampled and agitated with solvents and centrifuged to isolate the supernatant. The supernatant was subsampled and solvent exchanged for analysis by liquid chromatography Orbitrap mass spectrometry in electrospray negative ionization using full scan (100-1000 m/z) and data-dependent collision spectra (ddMS2). A custom workflow in Compound Discoverer software was developed to filter the data. To detect PFAS features in the leachate, the workflow applied tools such as Kendrick mass defect analysis for CF_2 and CF_2O, comparisons of polymer leachates to blanks, assessment of replicate variance, and peak quality filters. These criteria supported assignment of detected features as PFAS, and grouping into “families”. A PFAS family was defined as a homologous series of features differing by CF_2 or CF_2O. Using this workflow, 36-74 different families of PFAS were identified in the leachate, depending on the manufacturer or lot number. The isotope pattern indicated some multi-charged features, likely facilitating the ionization of high molecular weight substances. In total, over 500 discrete PFAS were identified in the leachate.In addition to mass spectrometry analysis, fluorine NMR was used to investigate the structure and composition of both the fluoropolymer leachate and bulk polymer, providing a comprehensive overview of both small molecule and large molecular weight components of the sample.

Disclaimer/Disclosure: This research was funded by the Chemicals Management Plan

4.19.T-06 Nontargeted Study of Firefighter Chemical Exposures During Southern

California Wildfires in 2024-2025

Thomas Young[1], Luann Wong[1], Derek Urwin[2], Mitchell McCartney[1], Cristina Davis[1], Nuen Tsang Yang[1] and Shehnaz Hussain[3] (1)University of California Davis (UC Davis), (2)University of California Los Angeles (UCLA), (3)University of California Davis

Wildfires are growing in frequency, extent and severity and they increasingly impact wildland-urban interfaces (WUI). The mixture of chemicals that firefighters are exposed to in WUI fires and the health impacts of these exposures are not clear, making it important to more comprehensively assess these exposures by going beyond target chemical lists used in typical combustion experiments. This study, part of a larger collaboration between the Los Angeles County Fire Department and University of California researchers, employed stationary active air sampling using sorbent tubes positioned at the engine location, silicone wristbands worn by firefighters during field operations, and skin wipes at the end of firefighting shifts to capture exposures. Gas chromatography-quadrupole time-of-flight mass spectrometry (GC-QTOF-MS) was used to identify chemicals captured on wristbands and skin wipes and to assess their relative abundances across samples. Sorbent tubes were used to quantify a suite of volatile and semivolatile organic compounds by unit resolution GC-MS. Samples were collected from five major fire events between September 2024 and January 2025 (Line, Bridge, Franklin, Eaton and Palisades Fires). The wristbands provided more comprehensive chemical exposure information than skin wipes. An automated classification algorithm annotated 424 features at level 1 or 2 confidence (out of the 1467 features that passed blank and signal to noise filters). Although experimental evidence regarding carcinogenicity was not available for most of the annotated structures, 76 of the compounds were predicted to be carcinogenic with “good reliability” by at least one quantitative structure activity relationship (QSAR) model within the VEGA platform. Relationships between exposure to the predicted carcinogens and fire characteristics will be discussed. These results suggest that nontargeted approaches to characterizing firefighter chemical exposure during WUI fires can expand our understanding of toxic chemical exposures.

Disclaimer/Disclosure: University of California, Office of the President, Climate Action Seed Award R02CP7431
National Institute of Environmental Health Sciences P30ES023513

Innovative Mass Spectral and Chromatographic Analyses Applied to Ecotoxicology and Environmental Monitoring

4.19.P-We207 Nontargeted Mass Spectrometry Analysis of Water Exometabolome and Plasma Metabolome From Fathead Minnow Acetochlor Exposure

Phillip Ankley[1], Camille Baettig[1], Jenna Cavallin[2], Mackenzie Nash[3], Kathleen Jensen[2], Heather Brown[2] and Daniel Villeneuve[2] (1)ORISE U.S. EPA, (2)U.S. Environmental Protection Agency (US EPA), (3)Oak Ridge Institute for Science and Education (ORISE)

Acetochlor is a selective pre-emergent chloroacetanilide herbicide that inhibits long-chain fatty acid synthesis and exhibits nontarget toxicity to aquatic organisms. Once released into aquatic systems, acetochlor can undergo abiotic and biotic transformation, yet the fate of the parent compound and the suite of transformation

products generated during fish exposure remain poorly characterized. Nontargeted metabolomics offered a single analytical workflow to detect both acetochlor transformation products (TPs) and endogenous metabolites released into the surrounding water (exometabolome). These metabolites can be mechanistically indicative of organismal response and can also be used to calculate the concentration at which a chemical elicits a concerted change in the (exo)metabolome (metabolomics-based point of departure (mPOD)). Adult fathead minnows (three males and three females per tank) were exposed aqueously to eight concentrations of acetochlor with a solvent control using a flow-through system for 96 h. Water samples were collected and extracted at 48 h and 96 h for exometabolome analysis, and plasma was collected terminally for endogenous metabolome analysis, with all samples analyzed by high-resolution mass spectrometry. Core exometabolome mPODs were consistent between 48 h (273.5 µg/L) and 96 h (271.9 µg/L) despite an increase in dysregulated features over time (4 vs 50) and were protective relative to the published zebrafish 96-h LC50 (2900 µg/L). Several acetochlor TPs were detected in exposure water, including 2-Chloro-N-(2-ethyl-6-methylphenyl) acetamide, glutathione-conjugated TP, and terminal desaturated acetochlor, with additional unknown acetochlor-related TPs still under investigation. The plasma metabolome revealed sex-specific responses: females had a substantially lower mPOD (12.0 µg/L) than males (286.5 µg/L). Tryptophan and acylcarnitines decreased in both sexes, while 11-ketotestosterone decreased in males and glutathione cycling was perturbed in females. Together, these results demonstrate that exometabolomics can concurrently resolve acetochlor transformation and organismal response using a single workflow and non-destructive sampling over a time course. Features detected in the exometabolome are being compared to those present in the plasma metabolome.

Disclaimer/Disclosure: The contents of this abstract neither constitute, nor necessarily reflect, US EPA policy.

4.19.P-We208 Spatial Mapping of PFOS and PFOA Reveals Differential Bioaccumulation Patterns in Zebrafish via Mass Spectral Imaging With Single- and Multi-Pass Ion Mobility Separation

Emmanuelle Claude[1], Matthew Smith[2], Angelica Diaz Basabe[3], Joann Ballantyne[1], Craig Wheelock[4], Lindsay Hatch[1] and Alex Birsan[1] (1)Waters Corporation, (2)Institute of Environmental Medicine, Karolinska Institute, (3)Center for Molecular Medicine (CMM), Karolinska University Hospital, (4)Karolinksa Institutet (KI)

Per- and polyfluoroalkyl substances (PFAS) are a well-known group of chemicals that have a variety of commercial and consumer uses. A key toxicological concern is the ability of PFAS to bioaccumulate, binding to proteins in blood and tissues rather than fat. This unique property allows PFAS to persist in organisms for years, leading to chronic exposure even at low environmental concentration. Unlike traditional bulk analysis by LC mass spectrometry, mass spectrometry imaging (MSI) allows the mapping of molecules directly in tissues.

In this work, we used desorption electrospray ionization (DESI) combined with an ion mobility-enabled Q-Tof mass spectrometer to evaluate the distribution of PFOS and PFOA as well as endogenous molecules directly from zebrafish that have been exposed to PFAS-contaminated water. Zebrafish were randomly divided into 3 groups, 1 male and 1 female per group. They were placed in 2L plastic tanks filled with 1L of system water. Treatments were given in the swimming water for the 3 groups: 1) Control group, 0.1% DMSO; 2) Perfluorooctanoic acid, 10 µM; 3) Perfluorooctanesulfonic acid, 10 µM. Exposure water was changed daily for seven days.

Zebrafish were sacrificed via thermal shock then cryo-sectioned onto standard glass slides. Samples were analyzed using a DESI XS source mounted on a SELECT SERIES™ Cyclic™ IMS mass spectrometer. The DESI MSI analyses were performed in single pass IMS untargeted full scan MS mode to enable detection of PFAS, as well as metabolites and lipids in both negative and positive ionisation modes to provide comprehensive molecular coverage. In negative mode, the ion mobility of PFAS species can be easily distinguished from singly charged tissue endogenous molecules, which have a longer drift time compared to PFAS ions. PFOS was distributed throughout the zebrafish, but it was primarily accumulated in the gills, digestive system and surrounding the eye, whereas PFOA was mainly localised in the gills and less into the digest organs. Using a cyclic IMS device, it was further possible to increase the number of ion mobility passes to differentiate the linear and branched PFOS isomers. Using this approach, branched isomers were observed in a different spatial distribution than linear PFOS.

4.19.P-We209 Source Tracking of Anthropogenic Pollution in Biscayne Bay Through Chemical Tracer and Nontarget Analysis

Eden Fergiev[1], Camille Demaire[1], Jennifer Rehage[1] and Kassidy Troxell[1] (1)Florida International University (FIU) Institute of Environment

Biscayne Bay is a highly urbanized subtropical estuary experiencing increasing pressure from anthropogenic inputs, including wastewater-derived contaminants and emerging pollutants. This study evaluated the spatial distribution of chemical tracers alongside non-target high-resolution mass spectrometry (NTA) to characterize chemical fingerprint and pollution sources influencing across west-east transects of the bay. 61 surface water samples were collected along 9 transects of nearshore urbanized regions to offshore environments. Nontarget analysis was conducted using online solid-phase extraction (SPE) with heated electro spay ionization high-performance liquid chromatography high-resolution mass spectrometry (HESI-HPLC-HRMS) on a Q Exactive Orbitrap (Thermo). Chemical tracers analysis was conducted by selected reaction monitoring via online SPE mixed mode HESI-HPLC-MSMS on a TSQ Altis Plus (Thermo). Chemical tracers including sucralose concentrations exhibited clear spatial gradients by decreasing eastwards, consistent with dilution and dispersion of land-based wastewater-related inputs. Correlation analysis, revealed weak relationships between sucralose concentrations and both the number of non-target compounds ($r = -0.16$; $\rho = -0.21$) and total signal intensity ($r = 0.27$; $\rho = 0.32$), with a moderately positive relationship between chemical complexity and signal intensity ($r = 0.46$; $\rho = 0.51$). Non-target analysis identified substantial variability in the number and composition of detected compounds across transects, with up to 561 features identified in individual samples. Some of the contaminants probable identified by non-target analysis included surfactants, pharmaceuticals, personal care products and natural compounds. These findings highlight the complexity of contaminant distributions in urban coastal systems and demonstrate that while chemical tracers like sucralose are effective markers of wastewater influence, it does not directly reflect overall chemical diversity. Overall, this study underscores the importance of integrating additional targeted tracers with non-target analysis to better understand contaminant sources, transport, and environmental processes in Biscayne Bay.

4.19.P-We210 Determination of Thiol Reactive Gaseous Atmospheric Chemicals With Passive Air Sampling Using Nontargeted Analysis of Glutathione Adducts

Alexander Kasperkiewicz[1], Jenny Oh[1], Kirsten Yeung[1], Hayley Hung[2], Yushan Su[3], Frank Wania[1] and Hui Peng[1]

(1)University of Toronto, (2)Environment and Climate Change Canada (ECCC), (3)Ministry of the Environment, Conservation and Parks

Gas-phase air pollutants are recognized contributors to oxidative stress and adverse health outcomes, yet research has focused on chemicals bound to particulate matter. Thus, the identity of gaseous toxicants, particularly electrophiles capable of depleting cellular thiol antioxidants, remains poorly characterized. Here, we couple passive air sampling (XAD-PAS) with a nontargeted "Thiol-Reactome" workflow and cellular reporter assays to identify thiol-reactive gaseous chemicals along a transect adjacent to a high traffic volume highway in Toronto, Canada.

Polar and non-polar air extracts were screened for oxidative stress using MCF7 cells stably transfected with an NRF2-luciferase reporter and incubated with a 1:1 mixture of native and stable-isotope-labelled glutathione (GSH) before analysis by LC-HRMS. Isotopic-ratio filtering, blank subtraction, and characteristic MS2 fragments allowed for confident isolation of GSH-electrophile adducts, followed by formula and structure prediction.

NRF2 reporter responses were elevated at highway-adjacent sites, with the strongest response at a sampler situated for direct airflow from highway emissions, mirroring spatial trends observed in the nontargeted feature data. Dozens of GSH adducts were detected, several correlating strongly with NRF2 fold-change (R up to 0.78) and candidate electrophile structures are proposed via accurate-mass formula prediction and MS2 confirmation.

These results establish GSH-adduct nontargeted analysis of passive samplers as a route to identifying the specific chemicals driving gas-phase oxidative stress near traffic sources.

4.19.P-We211 Comparison of Liquid Chromatography to Supercritical Fluid Chromatography for Triple Quadrupole Mass Spectrometry Analysis of Rubber-Derived Contaminants

Nipuna Senanayake[1] and Shira Joudan[1] (1)University of Alberta

Rubber-derived contaminants are emerging environmental pollutants released through the degradation of rubber-based materials, including tires, industrial rubber products, and consumer rubber goods. Compounds such as N-(1,3-dimethylbutyl)-N′-phenyl-p-phenylenediamine (6PPD), 6PPD-quinone, and diphenyl guanidine are of increasing concern because of their potential ecological toxicity. Liquid chromatography (LC) coupled with mass spectrometry is widely used for analysis of these contaminants; however, challenges remain regarding matrix effects, chromatographic selectivity, solvent consumption, and analysis time. Supercritical fluid chromatography (SFC) is an emerging analytical technique that uses compressed carbon dioxide and organic modifiers as the mobile phase. Although widely used in pharmaceutical and chiral analyses, the application of the SFC to rubber-derived environmental contaminants remains limited. This study compares a Waters Acquity UPLC (LC) to a Waters Acquity UPC2 (SFC), both coupled to the same Waters Xevo TQ-S Micro triple quadrupole mass spectrometer for the analysis of rubber-derived contaminants in environmental samples. LC method development will be conducted using a Kinetex XB-C18 reversed-phase column (1.7 µm, 100 Å, 50×2.1 mm), which outperformed other column chemistries evaluated. SFC method development will begin with a Waters Viridis BEH column (1.7 µm, 130 Å, 100×3 mm), and additional stationary phases will be

assessed to optimize the separation of the target contaminants. Preliminary LC method development for 15 rubber-derived contaminants, including antioxidants, has demonstrated limits of detection below 0.25 ng/mL. The SFC method development will subsequently be initiated and evaluated against the LC approach, based on retention behavior, peak shape, selectivity, matrix suppression, detection limits, reproducibility, and solvent consumption, for the analysis of rubber-derived contaminants. It is hypothesized that the SFC method will provide improved selectivity and faster separations for hydrophobic rubber-derived contaminants due to the low viscosity and high diffusivity of supercritical fluids, while also reducing organic solvent consumption. This work aims to improve the understanding of alternative chromatographic approaches for environmental contaminant analysis and support the development of faster and more sustainable analytical methods for emerging pollutants.

Non-Targeted Analysis and High-Resolution Mass Spectrometry in Environmental Chemistry

4.21.T-01 Non-Target Organic Chemical Characterisation of Storm Overflow Discharges and Receiving Waters Across Three South West England River Catchments in the UK: A Multi-Instrument Screening Approach

Garry Codling[1], Charles Tyler[1], Ross Brown[1], Nefeli Boni-Kazantzidou[1], Christopher De Wolf[1], Danielle Kay[1] and James Thomas[1] (1)Exeter University

Increasing population pressure and climate-driven intensification of rainfall are placing ageing combined sewer systems under stress, leading to more frequent releases of untreated wastewater. Storm event discharges—including combined sewer overflows (CSOs), settled storm overflows (SSOs), and surface water overflows (SWOs)—are recognised but poorly characterised sources of organic contaminants to UK freshwaters. Regulatory monitoring focuses on bulk physico-chemical indicators, leaving the diversity of organic pollutants and associated risks largely unresolved.

This study presents a pilot investigation of the organic chemical composition of storm overflow discharges and their influence on receiving rivers across three catchments in Southwest England. Sampling was conducted during winter 2025–2026 under exceptionally high rainfall conditions. Composite samples were collected from overflow discharge points (CSOs, SSOs, SWOs), final effluent, and paired upstream–downstream river locations across eight sites. Non-target screening was performed using high-resolution mass spectrometry, with GC-Orbitrap as the primary analytical platform and complementary LC-Orbitrap analysis. Solid-phase extraction (Oasis HLB; 4,800× enrichment) enabled cross-matrix comparison. Halogen-specific isotope screening, combined with spectral libraries and retention time prediction, was used to identify chlorinated and brominated compounds.

More than 600 compounds were tentatively identified by GC-HRMS and over 300 by LC-HRMS direct infusion, spanning industrial chemicals, pharmaceuticals, pesticides, personal care products, antibiotics, illicit drugs, and flame retardants. Halogenated compounds represented a substantial fraction of detections. Overflow samples contained up to 1,750 detected features, with estimated total concentrations exceeding 0.1 mg/L. Antibiotics (e.g., azithromycin) and illicit drug residues confirmed wastewater signatures, while downstream

enrichment indicated persistence of contaminants in receiving waters.

These findings demonstrate that storm overflows deliver complex mixtures of organic contaminants, including a previously undercharacterised halogenated fraction not captured by routine monitoring, highlighting the need for improved risk-based assessment and regulatory approaches.

Disclaimer/Disclosure: This work was supported by the Centre for Resilience in Environment, Water and Waste (CREWW) at the University of Exeter, in collaboration with South West Water, UK.

4.21.T-02 Identifying Chemical Tracers and Sources in South Florida Groundwater Using Non-Target Analysis

Mary Cavanaugh[1], Kassidy Troxell[1] and Piero Gardinali[2] (1)Florida International University, (2)Florida International University (FIU) Institute of Environment

Groundwater is a key resource of freshwater for South Florida and the Miami-Dade County (MDC) metropolitan area. Used in human consumption, regulating ecosystem function, and flood control, it also acts as a contributor to the Biscayne Bay estuary system. Contamination of this resource has led to degraded water quality within the Bay itself and has impacted ecosystems, public health, and the main economic activity in the area, tourism. Thus, identifying contaminants and their likely sources that impact the quality of groundwater using chemical organic tracers is a priority. Eleven groundwater wells throughout MDC were sampled eleven times within a year-long period. Non-target analysis (NTA) was performed using online-SPE-HPLC-HRMS (Q-Exactive Orbitrap, Thermo) to identify unexpected compounds in the groundwater. Frequently detected compounds and their uniqueness to certain sites were prioritized as potential source tracers. Tracers of wastewater, agriculture, and urban stormwater were subsequently quantified using online-SPE-HPLC-MS/MS (TSQ Altis Triple Quadrupole, Thermo) to support source apportionment. Correlations between water quality parameters, nutrients, metals, and organic and inorganic tracers were evaluated in order to identify relationships between contaminants and potential sources. Among these, statistically significant correlations were identified between the number of probable identified compounds (Level 2b) and sucralose (conservative wastewater tracer) concentrations ($p = 0.69$). Principal component analysis for both positive and negative ionization modes showed three sites that were unique. This is likely due to the detections at these sites belonging primarily to pharmaceuticals and pharmaceutical transformation product compound classes, unlike the remaining sites. Other compounds detected include additives to personal care products, herbicides, and markers associated with stormwater, industrial wastewater, and wastewater treatment plant effluent. The strong, statistically significant correlations to sucralose could be indicative of treated wastewater in some sites. The herbicides tebuthiuron and terbucarb, and the corrosion additive 5-methylbenzotriazole were probable identified compounds with >70% detection frequency in the sites. Other commonly identified compounds could potentially serve as tracers for groundwater intrusion in other parts of the heavily interconnected watershed once targeted and quantified.

4.21.T-03 Nontarget Prioritization Using Cell Bioassays and Chemical Modeling: A Pilot Application of MLInvitroTox for Sediment

Anna Feerick[1], Bushra Khan[1], Bryn Phillips[1], Manoela Romano De Orte[2], Erica Kalve[2], Lena Aisch[3], Juliane Hollender[3] and Thomas Young[1] (1)University of California Davis (UC Davis), (2)California State Water

Resources Control Board, (3)Swiss Federal Institute of Aquatic Science and Technology (Eawag)

With the increasing diversity of anthropogenic contaminants entering ecosystems, new techniques are needed that expand beyond targeted analytes and identify potentially unmonitored chemical drivers of toxicity. Nontarget analysis (NTA) is an a priori method capable of detecting and identifying contaminants not routinely measured; however, elucidating toxicity drivers is made challenging by the thousands of features generated from NTA per sample. With complete structural elucidation not yet feasible due to the need for manual validation, methods are needed to prioritize features of concern. Here, we prioritize features of concern using peak height and the response of five in vitro chemically activated luciferase gene expression cell bioassays (CB-CALUX) (aryl hydrocarbon receptor (AhR), peroxisome proliferator-activated receptor alpha (PPARα), estrogen receptor alpha (ERα), glucocorticoid receptor (GR), and antiandrogen receptor (AR)), to direct identification efforts towards compounds correlated with toxicity. To test this approach, in 2023, 18 sediment samples were collected and analyzed for NTA & CB-CALUX response. Nontarget features were detected using liquid chromatography with high-resolution mass spectrometry (LC-HRMS). Samples with the highest activity for each CB-CALUX underwent iterative MS/MS, and results were processed through an in silico structure prediction software (SIRIUS). We also tested a high-throughput hazard-based prioritization software, MLInvitroTox, trained on the ToxCast21 database to predict bioassay activity based on SIRIUS molecular fingerprints. We applied 34 MLInvitroTox models to our SIRIUS iterative MSMS results, consisting of two AhR and 32 ERα endpoints. Ongoing work focuses on performing comparative analysis between MLInvitroTox and the bioassay prioritization scheme, as well as selecting features for confirmation, with a focus on those predicted to be assay activators based on the US EPA's ToxCast software or by both MLInvitroTox and bioassay correlation.

4.21.T-04 Using Non-Targeted Analysis To Assess the Impacts of Reclaimed Wastewater Use for Crop Irrigation

Sara Nason[1], Raees Ahmad[1] and Nubia Zuverza-Mena[1] (1)Connecticut Agricultural Experiment Station

Reuse of treated wastewater for crop irrigation is an important water conservation strategy, but many contaminants are present in wastewater that may transfer to the edible portions of crop plants. In addition to contaminants that enter wastewater prior to treatment, many chemical transformation processes occur during treatment, storage, and plant growth. These transformations may generate additional bioactive contaminants that are unlikely to be on any targeted screening lists. We collected paired influent and effluent wastewater samples, and to test a worst-case scenario, we grew microgreens hydroponically directly in the wastewater effluent. All samples were analyzed using liquid chromatography – high resolution mass spectrometry. Data was subjected to quantitative targeted analysis, database screening for additional contaminant identification, molecular networking, and quantitative non-targeted analysis methods to assess contaminant transformation pathways as well as the toxicity risk of contaminants accumulated in the plants. We found multiple clusters of related contaminants and their transformation products including pharmaceuticals, hormones, industrial chemicals, and pesticides. While matrix effects severely impacted the data, non-targeted analysis ultimately proved to be a highly useful tool for assessing risks of reclaimed wastewater use for irrigation.

4.21.T-05 Characterization of Volatile Chemicals in the Atmosphere of New York City via a Novel Suspect Screening Workflow

Christopher Brunet[1], Nora Gibson[1], Rachel Marek[1] and Keri Hornbuckle[1] (1)University of Iowa

Non-target and suspect screening analysis are increasingly used to characterize complex environmental mixtures, but their application to ambient outdoor air remains sparse. Existing studies have largely focused on aqueous, biological, and solid matrices amenable to LC-HRMS, and comprehensive screening of gas-phase contaminants is limited to a handful of studies. The urban atmosphere is particularly poorly characterized. This gap has real consequences, as a growing body of work suggests urban VOC emissions are shifting from legacy sources such as automobiles toward industrial and consumer volatile chemical products (VCPs) whose emission profiles are not fully known. Progress has also been slowed by a lack of standardization and reproducibility with much of the field still relying on custom, non-comparable workflows.

Here we present a comprehensive suspect screening workflow for outdoor urban air that combines high-volume active sampling on XAD-2 resin, a non-destructive extraction and cleanup method designed to retain a broad chemical space, and a completely open-source data analysis pipeline that provides end-to-end, reproducible Level 2 annotations following the criteria of Koelmel et al. In addition to development of this workflow, we describe its application to time-resolved samples collected in New York City during summer 2022. This dataset contained a total of 47 unique features which the Level-2 screening criteria resolving to 95 unique chemical structures spanning monocyclic and polycyclic aromatic hydrocarbons, aromatic heterocyclics, phthalates, monoterpenes, esters, aldehydes, and nitrogen-containing aromatics. The identified chemicals are largely originate from chemical products such as fragrances, personal care products, cleaning solutions, and building materials, providing further evidence that urban VOC burdens are increasingly dominated by VCP emissions. We also report several novel or unexpected findings, including the first atmospheric identification of 2-phenylpropanal, an unexpectedly high relative abundance of dibenzofuran, and a less confident but novel identification of 4-vinylpyridine. We present this work as a step toward the standardization of air-based NTA/SS rather than a final recommendation, and discuss its limitations along with recommendations for future urban screening campaigns.

Disclaimer/Disclosure: This study was supported by the National Science Foundation (grant: 2028764) and the National Institute of Environmental Health Sciences of the National Institutes of Health (NIEHS/NIH) under award number P42ES013661.

4.21.T-06 Non-Targeted Analysis of San Francisco Bay Water, Sediment, and Pathways To Inform Regional Monitoring of Emerging Contaminants

Ezra Miller[1], Lee Ferguson[2], Luann Wong[3], Thomas Young[3] and Rebecca Sutton[1] (1)San Francisco Estuary Institute, (2)Duke University, (3)University of California Davis (UC Davis)

The Regional Monitoring Program for Water Quality in San Francisco Bay (RMP) is an innovative collaboration between regulatory agencies, the regulated community, and scientists working to identify and inform priority questions faced by Bay water quality managers. Thanks to the region's sustained focus, San Francisco Bay (California, USA) is one of the most well-studied aquatic ecosystems for emerging contaminants, which are broadly defined as chemicals that are un- or under-regulated, not commonly monitored in

environmental media, and have the potential to enter the environment and cause adverse ecological or human health impacts. Over the past decade, the RMP has invested considerable resources in non-targeted analysis (NTA) of multiple Bay matrices as a tool to inform follow-up targeted analysis and risk screening studies of emerging contaminants. Using NTA, the RMP has tentatively identified hundreds of contaminants in Bay water, sediment, and pathways to the Bay (municipal wastewater effluent and stormwater runoff). These efforts have helped to identify urgent science priorities and have directly led to targeted studies addressing some of the most readily identifiable compounds, such as tire-derived contaminants and ethoxylated surfactants. Overall, results indicate significant burdens of emerging organic contaminants in San Francisco Bay water and sediments, especially in south Bay coastal margin areas proximal to stormwater outfalls and municipal wastewater discharges. Now, the RMP continues to implement cutting-edge NTA science by screening urban runoff samples for novel contaminants and coupling NTA of Bay water and wastewater with a suite of in vitro bioassays to identify bioactive compounds. Here, we present the RMP's past and current NTA work as a case study on the challenges and successful design and implementation of NTA studies to inform a broad array of stakeholders and ultimately, the management of urban contaminants entering surface waters.

Disclaimer/Disclosure: This work was funded by the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP).

Non-Targeted Analysis and High-Resolution Mass Spectrometry in Environmental Chemistry

4.21.P-Th147 Combining Nontargeted Analysis With In Vivo and In Vitro Bioassays To Identify Chemicals of Toxicological Significance in the Waters of San Francisco Bay

Thomas Young[1], Luann Wong[2], Brenda Mengeling[2], J. David Furlow[1], Ezra Miller[3] and Rebecca Sutton[3] (1)University of California Davis (UC Davis), (2)University of California Davis, (3)San Francisco Estuary Institute

Urban estuaries receive inputs from a wide variety of point and nonpoint sources that contain an increasing diversity of largely unmonitored constituents. Assessing the effect of these inputs on the health of the estuary ecosystem demands novel bioanalytical approaches combining chemical and biological screening. In this study a combination of nontargeted chemical analysis using liquid and gas chromatography with high resolution mass spectrometry was applied alongside a suite of bioassays ranging from cell reporter assays to whole organism tests. Grab samples were collected from 22 locations in San Francisco Bay during the dry season and 27 locations during the wet season (2025-26). Samples of effluent from three wastewater treatment plants discharging to the Bay were also collected. Samples were processed by solid phase extraction, cartridges were eluted to recover retained compounds, and the extracts were split and solvent exchanged as needed to produce dedicated extracts for analysis using GC-HRMS, LC-HRMS and bioassays. We assessed potential thyroid activity of extracts first using a reporter gene cell line (GH3.TRE-Luc) that expresses all binding forms of the thyroid hormone receptor (TRα1, TRβ1, TRβ2); significant agonist activity was detected for one of the three wastewater effluents tested, but no significant agonist or antagonist activity was detected in other samples. We applied a Xenopus laevis tadpole induced, precocious metamorphosis assay to test for thyroid hormone and retinoid-X receptor (RXR) signaling in vivo, which includes morphological analysis of multiple target tissues

(head and jaw remodeling, brain expansion, tail resorption); no significant effect on thyroid signaling were detected with the assay. To test for estrogen receptor activity, we employed a cell reporter assay (VM7-Luc) that expresses both ERα and ERβ forms of the estrogen receptor. All three wastewater effluent samples exhibited average reporter assay responses that exceeded those observed for 200 pM of estradiol, while many of the Bay water samples exhibited significantly elevated ER agonist responses compared to laboratory and field blank samples. Additional work is being conducted to add to the suite of applied nuclear receptor assays and to perform comprehensive nontargeted sample analysis. The wide range of fold changes observed provides a promising opportunity to apply virtual effects-directed analysis to identify thyroid and estrogen receptor active compounds.

4.21.P-Th148 Beyond Targeted per- and Polyfluoroalkyl Substance Analysis: Exploring Hidden Chemical Space in Drinking Water Treatment Using High Resolution Mass Spectrometry

Emir Nazdrajić[1], Allysa Greidanus[1], Dawson McLachlan[1] and Scott Hopkins[1] (1)University of Waterloo

Per- and polyfluoroalkyl substances (PFAS) are a large and diverse class of synthetic chemicals that have accumulated in the environment despite restrictions on select compounds. In many regions, wastewater effluents are discharged into water bodies upstream of drinking water treatment plants' intakes, creating a feedback loop that sustains PFAS circulation. Within this context, conventional treatment processes often exhibit a “PFAS in = PFAS out” condition, in which overall removal is limited, and contaminant mixtures are assumed to remain unchanged. While targeted analyses provide important insights, they overlook the broader spectrum of unknown PFAS, including unknowns and transformation products. Although non-target approaches remain limited by reproducibility and access to high-quality spectral resources, this work introduces a new workflow designed to improve analytical robustness and enable the identification and characterization of PFAS. Lorne Park Water Treatment Plant (collected January 2026) has provided four weekly composite samples from raw water, between all water treatment stages, and treated water (from both conventional and advanced treatments), totalling 36 samples. Targeted PFAS analysis has been completed using a liquid chromatography tandem mass spectrometry system. The unique non-target PFAS workflow includes software and algorithms for identifying and characterizing unknowns, which has been effective at identifying various PFAS class candidates for other applications.

The preliminary results show several sulfonic and carboxylic group PFAS detected and quantified. The sum of quantified PFAS in conventional and advanced treated water is well below Health Canada’s objective (of 30 ng L-1) at 12.3 and 11.8 ng L-1, respectively. Interestingly, 6:2 fluorotelomer sulfonate showed up above, and later diminished below, the limit of quantitation during the advanced treatment. We also detect a perfluorooctanesulfonamide, a known PFAS transformation product linked to the production by chlorination. Future work focuses on detailed interrogation of results from data-dependent and all-ion-fragmentation data and assigning the PFAS candidates to a modified Schymanski scale. These findings highlight the importance of applying more comprehensive analytical strategies in surface waters that supply drinking water, where incomplete characterization may obscure the true dynamics of contaminants.

Disclaimer/Disclosure: This work is funded by NSERC through the Alliance Grant (ALLRP-571095-21) and is supported by the sponsored research agreement between the Peel Region and the University of Waterloo.

4.21.P-Th150 Contact Lenses As Wearable Samplers for Non-Targeted Chemical Exposure Assessment

Sara Vaezafshar[1], Norah H. B. Beach-Diplock[1], Meera Shanmuganathan[1] and Joseph Okeme[1] (1)Department of Chemistry & Chemical Biology, McMaster University

A critical barrier to reducing the global burden of disease linked to environmental exposures is the absence of accessible tools that can reliably characterize chemical exposure. This exposure includes diverse chemical classes such as per- and polyfluoroalkyl substances (PFAS), phthalates, and their transformation products. Improved exposure assessment technologies are essential for identifying which chemicals pose the greatest health risks. Tear fluid is a promising matrix for such assessments, yet current collection methods (e.g., Schirmer strips and microcapillary tubes) yield limited volumes and can induce reflex tearing, increasing variability in biomarker profiles. To address these limitations, we introduced worn contact lenses as passive samplers capable of capturing time-weighted measurements of biomarkers in tear fluid.

Our objective was to characterize the diversity of endogenous and exogenous chemicals captured by worn contact lenses using non-targeted Q-TOF-HPLC. We also aimed to evaluate temporal (weekday vs. weekend) and non-temporal (between-participant variability) varibility in chemical profiles. In addition to non-targeted analysis, we quantified six neurochemical markers (i.e., cortisol, epinephrine, norepinephrine, oxytocin, serotonin, and dopamine) using targeted LC-MS/MS. Ten undergraduate students from McMaster University with no history of ocular disease participated in the study. Each participant wore three pairs of daily contact lenses on weekdays and three pairs on weekends, representing time spent primarily at work versus at home.

Our findings showed that worn contact lenses can capture (1) a broad range of endogenous and exogenous chemicals and (2) both temporal (weekday vs. weekend) and non-temporal (between-participant) variability. Non-targeted analyses revealed distinct chemical profiles between the two sampling periods, enabling the prioritization of specific compounds for future targeted measurement. Targeted analysis detected all neurochemical markers except epinephrine, with detection frequencies ranging from 41% for oxytocin to 98% for cortisol. Across all samples, norepinephrine was the most abundant neurochemical, whereas serotonin was the least abundant. Two-way ANOVA revealed no significant differences in neurochemical concentrations between weekdays and weekends. Our study showed the feasibility of contact lenses as an accessible sampling tool for assessing endogenous and exogenous exposures.

Disclaimer/Disclosure: Natural Sciences and Engineering Research Council of Canada: Discovery Grant, Alliance Grant, Undergraduate Student Research Award. The Canadian Foundation for Innovation. The McMaster Faculty of Science and the Department of Chemistry & Chemical Biology Start-up Funding.

4.21.P-Th151 Characterizing PFAS in Cosmetic Products Using Non-Targeted Acquisition

Craig Butt[1], Holly Lee[1], Mikyanny Reyes[1], Amy Rand[2], Keegan Harris[2], Christopher Via[1] and Kendra Adams[1] (1)SCIEX, (2)Carleton University

Per- and polyfluoroalkyl substances (PFAS) are widely used in cosmetic and personal care products due to their ability to impart water resistance and durability. However, increasing regulatory restrictions and evidence of human exposure via dermal absorption and ingestion highlight the need for more comprehensive analytical

approaches. A key challenge is that conventional targeted methods capture only a limited fraction of total PFAS and extractable organic fluorine present in these matrices.
This study aims to improve PFAS characterization in cosmetics using a non-targeted acquisition (NTA) workflow based on high-resolution mass spectrometry. Cosmetic products, including foundations, concealers, and creams were extracted and analyzed using LC coupled to a high-resolution quadrupole time-of-flight mass spectrometer (ZenoTOF 7600), with system modifications to reduce PFAS background. Data processing combined suspect screening with MS/MS library matching, diagnostic fragment ion confirmation, and automated fragment-based precursor searching.
Initial suspect screening identified multiple PFAS classes, including perfluorocarboxylic acids (PFCAs), fluorotelomer carboxylic acids (FTCAs), fluorotelomer unsaturated carboxylic acids (FTUCAs), and mono- and di-polyfluoroalkyl phosphate esters (monoPAPs and diPAPs), often as homologous series. Several commonly targeted classes, such as perfluorosulfonic acids (PFSAs) and emerging ether-based PFAS, were not detected. Expansion of the suspect list and use of diagnostic fragment ions enabled confirmation of additional PFAS not present in spectral libraries. Automated fragment-based screening further revealed previously unreported diPAP-like compounds.
These results demonstrate that integrating high-resolution MS/MS with diagnostic fragment and non-targeted workflows significantly expands PFAS detection beyond targeted approaches. This strategy enables more comprehensive characterization of known and novel PFAS in complex consumer products, supporting improved exposure assessment and informing regulatory and environmental monitoring efforts.

4.21.P-Th152 Characterization and Human Exposure to Amine-Based Curing Agents From Indoor Uses of Epoxy

Xianming Zhang[1] and Aida Yousefi[1] (1)Concordia University

Curing agents play an important role in epoxy resin systems, as they help the final material develop the required strength, durability, and overall performance. Among the various types of curing agents, amine-based curing agents are commonly used because they can cure rapidly at room temperature and produce epoxy materials with high hardness, good mechanical properties, and strong chemical resistance. Despite these advantages, amines can also present some concerns. Many of them have a strong odor and may cause skin or respiratory irritation, which makes their possible release into indoor environments an important issue for exposure assessment.
In this study, twelve commercial amine-based curing agent samples were purchased and investigated to better understand their chemical composition. Initially, non-target analysis and suspect screening were used to obtain a preliminary identification of the main compounds present in the samples. The next step was to prepare standard solutions and dilutions, followed by chromatography coupled to high-resolution mass spectrometry analysis, to confirm the target compounds selected through suspect screening in the formulations.
The next part of this study will focus on evaluating the emission behavior of the identified target compounds. For this purpose, polyurethane foam (PUF) sampling was used to measure the emission of target compounds. In addition, a multilayer mass-transfer model was developed to simulate the release of a chemical compound from an epoxy, its transport through a stagnant air layer, and its subsequent uptake by PUF. The model is based on Fick’s second law, and to solve the governing equation numerically, each domain was divided into multiple small layers. Therefore, the concentration profile of the compound can be calculated as a function of both time and position in each phase. At the interfaces between different phases, the model accounts not only for diffusion but also for partitioning. Moreover, the model includes the effect of epoxy curing. Finally, a sensitivity analysis

was performed.
Overall, this ongoing study aims to provide a practical workflow for identifying amine-based curing agents in commercial products and assessing their potential emissions into indoor air. The findings are expected to improve our understanding of indoor exposure to amine-containing compounds and may support future risk assessment of emissions from epoxy curing agents.

4.21.P-Th153 Insights and Considerations for Utilizing Nontargeted Analyses To Characterize PFAS

Erika Portero[1] and Lam H Leung[1] (1)Chemours Company

Background: Non-targeted analysis (NTA) using high-resolution mass spectrometry (HRMS) enables the characterization of previously unknown per- and polyfluoroalkyl substances (PFAS). This allows a deeper investigation of PFAS profiles for diverse samples (e.g., environmental, biological).
Challenge and problem: The identification of unknown PFAS requires a high level of selectivity and sensitivity. High-accuracy mass measurements by HRMS, which can be used to predict molecular formulas, provides a starting point for compound identification. Additional information acquired during the HRMS workflow, such as characteristic compound-fragmentation, negative mass-defect screening, and isotopic distribution lead to increased confidence in the assignment of an analyte structure. However, several challenges remain in the non-targeted analysis workflow to confidently identify compounds, including the need for: 1) standardized methods and reporting tools, since differences in experimental conditions (e.g., chromatography, mass analyzers) may result in varied datasets that can present inconsistencies; 2) achieving trace-level detection (below parts-per-billion) in complex sample matrices; 3) improving current screening workflows to minimize 'false positive' assignments; and 4) chemical standards to confirm compound identification.
Methods: To address these challenges, several approaches have been implemented. Expanded PFAS-specific databases and in silico generated spectral libraries improve MS/MS fragment annotation confidence. Knowledge of chemical manufacturing processes and/or synthetic fluorine chemistry are needed to propose accurate chemical structures and for the subsequent synthesis of authentic reference standards. This presentation will discuss examples of difficulties, limitations, and successfully identified analytes as part of the NTA investigation in collected water samples at the Chemours Fayetteville Works (FW). While initial results by suspect screening suggested the presence of several analytes proposed to be fluorinated, further investigations later identified them as nonhalogenated inorganics. Other cases include the incorrect assignment of molecular formula leading to prolonged timelines for full compound identification.
Results: Advances in HRMS-based NTA and computational tools (e.g., software upgrades) have resulted in higher identification confidence with fewer 'false positive' assignments.

4.21.P-Th154 Identification of Chlorination By-Products in Drinking Water Samples Prepared With EPA Method 1633 With High Resolution Mass Spectrometry

Pierre Dumas[1], Jessica Larose[1], Sarah Dowd[2], Lindsay Hatch[2], Alex Birsan[2] and Naren Meruva[2] (1)Québec's National Public Health Institute (INSPQ), (2)Waters Corporation

The growing concern regarding public health exposure to emerging disinfection by-products highlights the need for improved analytical strategies capable of identifying these compounds even at trace levels. In testing drinking water samples prepared with EPA Method 1633 for PFAS, unexpected analytical interferences were

detected affecting the quantification of short-chain compounds such as PFBA in drinking water. This observation served as the starting point for a broader investigation into previously unrecognized chlorinated by-products. Analyzing the same samples with high-resolution mass spectrometry enabled the identification of these by-products along with the target PFAS. The drinking water samples were analyzed with the Xevo™ MRT mass spectrometer (Waters Corporation) using the same chromatography method as the targeted assay for PFAS. An initial screening experiment with data-independent acquisition (MSe) was used for determining halogenated peaks of interest in the samples. For better compound identification, a follow up injection with data-dependent acquisition (DDA) was used with the masses of interest on an inclusion list for MS/MS. Using this approach, we report the detection and tentative identification of ten poorly characterized chlorinated and brominated compounds in drinking water. The presence and amount of the compounds varied across drinking water samples but were unique to samples that had undergone chlorination treatment. Potable water samples from well sources did not contain any of the disinfection by-products.

This study demonstrates that EPA Method 1633, when coupled with high-resolution mass spectrometry, possesses an extended analytical capability beyond targeted PFAS analysis. Specifically, the method enables the simultaneous detection and semi-quantitative screening of semi-volatile chlorination by-products present in potable water matrices. These findings underscore the added value of leveraging high-resolution mass spectrometry within established regulatory methods to expand laboratory monitoring capabilities and improve our understanding of emerging contaminants in drinking water.

4.21.P-Th155 Xenobiotic - Protein Interactome in Humans

Xing Qian[1], Jianxian Sun[2], Sofia Lemak[2], Tim Tao[1] and Hui Peng[1] (1)University of Toronto, (2)Structural Genomics Consortium

Humans encounter millions of dietary, environmental, and pharmaceutical xenobiotics daily, which modulate biological functions through protein interactions. However, with over 350,000 globally registered industrial compounds and 139,000 dietary natural products, evaluating the bioactivity of each compound using traditional methods remains unfeasible. To overcome this challenge, we present an ultrahigh-throughput affinity-selection mass spectrometry (AS-MS) platform to systematically map the human xenobiotic–protein interactome, bridging the vast chemical space with functional human proteins.
We prioritized over 3,000 exposure-relevant xenobiotics (dietary natural products, food additives, and ToxCast chemicals) based on LC-MS ionization efficiency. To achieve ultrahigh-throughput, an Opentrons robotic system was applied to screen these compounds against ~2,000 human proteins in 384-well plates, followed by LC-MS/MS analysis. The enriched hits (fold change > 5, $p < 0.05$) were validated by biophysical and functional assays. Our xenobiotic-protein interactome will provide an unprecedented opportunity to comprehensively discover the mechanistic insight between bioactive xenobiotics and human health.

Disclaimer/Disclosure: This project is supported by the Innovative Health Initiative Joint Undertaking and its members and contributing partners, Enamine, and The Hospital for Sick Children, under grant agreement No. 101252959.

Occurrence, Fate and Effects of Contaminants Across Waste and Wastewater Systems

4.22.T-01 PFAS in Activated Sludge Wastewater Treatment: Process-Level Insights Into Transformation, Partitioning, and Removal

Joseph Charbonnet[1], Juhe Liu[1], Samantha Good[2] and Edson Lopez[3] (1)Iowa State University, (2)University of Colorado, Boulder, (3)University of California, Berkeley

Municipal wastewater treatment plants (WWTPs) are important conduits for per- and polyfluoroalkyl substances (PFAS), yet the fate of PFAS within individual treatment processes remains incompletely understood. This study investigated the occurrence, transformation, partitioning, and removal of PFAS across three full-scale activated sludge WWTPs. Wastewater and sludge were collected from multiple treatment stages and analyzed for targeted PFAS. The Total Oxidizable Precursor (TOP) assay was applied to quantify untargeted perfluoroalkyl acid (PFAA) precursors. Conventional activated sludge treatment exhibited limited and highly variable removal of targeted PFAS, with plant-wide removal efficiencies ranging from negative values to approximately 30%. PFAS compositions were more strongly influenced by sewershed-specific source inputs than by individual treatment processes. However, aeration emerged as a critical process affecting PFAS fate, with increases in short-chain PFAAs and fluorotelomer transformation products indicating biological conversion of precursors. Untargeted PFAA precursors represented a substantial fraction of total PFAS throughout treatment, accounting for 23–70% of total PFAS mass and persisting in final effluents at concentrations up to 120 ng/L. Aeration promoted enrichment of linear PFOS, likely through a combination of precursor transformation and preferential partitioning to biomass, while clarification altered PFOS isomer distributions through solids settling. Sludge and suspended solids acted as important PFAS reservoirs, with PFBS exhibiting strong enrichment in biological solids. Mass balance calculations demonstrated that approximately half of influent PFAS-derived fluorine was emitted in the aqueous effluent, while a substantial portion—likely largely untargeted PFAS associated with sludge—remained unaccounted for. These findings demonstrate how activated sludge systems can transform and redistribute PFAS among aqueous and solid waste streams while providing limited overall removal. The results underscore the need for integrated analytical approaches combining targeted analysis, precursor assays, and isomer-specific measurements to more fully characterize PFAS occurrence and fate in wastewater treatment systems and to support effective contaminant management strategies.

Disclaimer/Disclosure: This work was supported by the Iowa Water Environment Association Research Grant Program.

4.22.T-02 Identifying the Sources of Industrial and Commercial Microplastic Pollution to Urban Wastewater in the Greater Toronto Area

Kayla Simpson[1], Paul Helm[2] and Miriam Diamond[1] (1)University of Toronto, (2)Ontario Ministry of the Environment, Conservation and Parks

Microplastic annual loads to the environment originating from urban/industrial/commercial locations can be billions of particles and constitute tonnes of plastics. Reducing these loads starts with identifying major sources and then devising effective control measures. We hypothesized that industrial/commercial facilities engaged in plastic manufacturing, distribution, and recycling are a significant source of microplastics to municipal

wastewater facilities, where these loads enter the environment either through treated wastewater effluent and biosolids or sludge. We tested this hypothesis by partnering with local municipalities to identify and characterize industrial/commercial sources of microplastic pollution entering the municipal wastewater system in the Greater Toronto Area. Grab samples (16 L) were collected at the point of discharge to the wastewater sewer system from 26 commercial facilities. Effluent and sludge grab and composite samples were also collected from wastewater treatment plants receiving effluent from these facilities via sewer discharges. Visual and FTIR analyses of microplastics >125 μm identified eight out of 26 industrial/commercial facilities as relatively high emitters, with concentrations reaching 694 particles/L and microplastics exhibiting distinct characteristics detectable in downstream wastewater treatment plant samples. Examples of discharged microplastics included PVC irregular microbeads from vinyl manufacturers, PE commercial shavings from plastic recyclers, and nylon fibers from a commercial laundry service. Facilities using on-site microfiltration of process water discharged at most 3.5 particles/L, suggesting the efficacy of certain on-site wastewater pre-treatment in removing microplastics. Overall, these results will provide municipalities with the evidence needed to enforce discharge bylaws and reduce microplastic emissions.

4.22.T-03 Suspect Screening of Volatile Organic Compounds in Air Surrounding Two Midwestern Wastewater Treatment Plants

Nora Gibson[1], Christopher Brunet[1], Rachel Marek[1] and Keri Hornbuckle[1] (1)University of Iowa

Non-target and suspect screening analysis have recently emerged as powerful tools for identifying unknown or under-characterized environmental contaminants. While these methods have been widely applied to the aqueous and solid matrices of wastewater treatment plants (WWTPs), their application to the ambient air surrounding these facilities remains limited. WWTPs are important but understudied sources of gas-phase contaminants, as aeration, agitation, and biological treatment can volatilize organic compounds from the influent and release them directly to the atmosphere. Ambient air sampling at WWTPs consequently offers a unique opportunity to characterize emerging volatile contaminants from diverse urban and industrial sources within a single system. In this study, we pair high-volume air sampling with a novel suspect screening workflow to compare volatile organic compound (VOC) emissions from two Midwestern WWTPs. The first plant serves a moderately sized city (~150,000 people) but receives substantial industrial inputs. The second serves a smaller city (~50,000 people) and treats primarily residential and commercial wastewater. Gas-phase air samples were collected directly above the aeration basin at each facility then extracted, cleaned up, and analyzed by high-resolution gas chromatography mass spectrometry. Mass spectral data were deconvoluted and annotated using a library-based suspect screening approach to provide tentative identifications of specific chemical structures and their relative abundances. Herein we describe the broad chemical fingerprint of each plant, highlight specific identifications of interest for their novelty or their human and environmental health implications, and present statistical comparisons of the features detected at both facilities. We further consider the likely sources of these compounds and differences based on distinct inputs of each plant's wastewater and the applied treatment processes. This work broadens the analytical scope of non-target and suspect screening techniques and improves our understanding of the volatile contaminants emitted during wastewater treatment.

Disclaimer/Disclosure: This study was supported by the National Institute of Environmental Health Sciences of the National Institutes of Health (NIEHS/NIH) under award number P42ES013661.

4.22.T-04 Suspect Screening and Temporal Trends of Anionic, Cationic, and Zwitterionic per- and Polyfluoroalkyl Substances in Canadian Biosolids From 2011 to 2023

Toyin Dunsin Saliu[1], Sarah Gewurtz[2], Gabriel Munoz[3], Anne Smyth[2] and Sébastien Sauvé[4] (1)University of Montreal (UdeM), (2)Science and Technology Branch, Environment and Climate Change Canada, Burlington, ON, Canada., (3)Centre d'expertise en analyse environnementale du Québec, ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs, Québec, QC, Canada., (4)Département de Chimie, Université de Montréal, Montréal, QC

The monitoring of per- and polyfluoroalkyl substances (PFAS) in municipal biosolids has largely been limited to a few target anionic compounds, while omitting a diversity of precursors. This represents a critical limitation for regulating PFAS as a broad class. This study expands on previous national monitoring efforts by quantifying 80 target anionic, cationic, and zwitterionic PFAS in Canadian biosolids. These PFAS were targeted in 101 biosolid samples collected from 30 wastewater treatment plants from nine Canadian provinces between 2011 and 2023. The Σ80 PFAS in Canadian biosolids ranged from 55 to 2321 µg/kg (mean: 334 ± 244 µg/kg), with regional variability reflecting differences in influent composition and treatment processes. Precursors such as fluorotelomer phosphate diesters (diPAPs, mean: 154±134 µg/kg; max: 624 µg/kg), fluorotelomer carboxylic acids (FTCAs/FTUCAs, mean: 79±98 µg/kg; max: 632 µg/kg), and fluorotelomer sulfonamidopropyl betaines (6:2 FTAB, mean: 27±217 µg/kg; max: 2181 µg/kg) were dominant contributors to total target PFAS and often exceeded concentrations of legacy compounds, including PFOA (mean: 5±12 µg/kg; max: 97 µg/kg) and PFOS (mean: 11±17 µg/kg; max: 124 µg/kg). Most of these precursors are not included in USEPA Method 1633A. While PFOA and PFOS in biosolids declined significantly over the study period, the overall ∑80 PFAS remained stable. Suspect screening revealed 14 additional AFFF-related PFAS in Canadian biosolids that may transform into persistent PFAAs following land application. Most biosolids complied with current Canadian and Québec guidelines for PFOS, PFOA, and ∑11 PFAS; however, these metrics captured only ~23% of total PFAS, highlighting the substantial contribution of unregulated compounds.

4.22.T-05 Fate of PFAS and PPCPs Present in Electrochemically Treated Biosolids for Potential Land Application

Andres Sanchez Garcia[1], Jedidian Adjei[1], Anushka Pandey[1], Christian Alvarez-Pugliese[1], Gerardine G. Botte[1], Danny Reible[1] and Balaji Anandha Rao[1] (1)Texas Tech University

The application of biosolids to agricultural land has been commonly practiced worldwide as it is considered beneficial to improve crop yields. Biosolids supply useful constituents such as macro-nutrients, organic matter, and micronutrients, reducing the need for other fertilizers. It is estimated that U.S. produces more than 8 million tons of municipal biosolids on annual basis, with about 60% of it is being land applied. Concerns about the application of biosolids onto land are related to pathogens, odors, organic contaminants, trace metals, and more recently, to PFAS and PPCPs. Contaminants introduced to agricultural soil through amendment with biosolids have the potential to accumulate to hazardous levels, migrate to deeper layers and leach into groundwater, or enter the food chain if being absorbed by biota. Given the lack of Federal Regulations, seven states in the U.S. have issued local regulations on PFAS concentrations for biosolids that seek to be land applied. In order to meet current regulations, biosolids might need to go under additional treatments as typical processes were not designed to deal with PFAS and PPCPs. Among documented treatments for PFAS removal/degradation from biosolids, incineration, hydrothermal liquefaction, thermal hydrolysis, supercritical water oxidation technology,

and pyrolysis, stand out. Even though multiple papers have reported the successful degradation of PFAS in water by means of electrochemical treatments, there is little to no information about those types of systems applied to biosolids.

In this work, an alkaline hydrolysis/electrochemical process originally designed for enhancing nitrogen recovery in biosolids will be tested to assess any potential capability to degrade PFAS and PPCPs. The system will be applied as a semi-batch reactor at pilot plant scale. Samples before and after electrochemical treatment will be analyzed to validate the removal performance of the proposed treatment process. A comprehensive characterization of PFAS listed on EPA Method 1633 and PPCPs listed in EPA Method 1694, will be carried out in an LC-HRMS. This work aims to assess the suitability of this electrochemical process as treatment method to comply with State-issued PFAS regulation on biosolids, while also aiming to reduce the knowledge gap around the identification and understanding of physicochemical processes behind PFAS and PPCPs transformation in complex environmental matrices by unexplored technologies.

4.22.T-06 Cross-Ecosystem Transfer of Microplastics via Emergent Aquatic Insects to Riparian Spiders in a Municipal Wastewater-Impacted System

Colleen Wardlaw[1], Karen Kidd[1], Brittany Perrotta[2], John Fast[1] and Ryan Prosser[3] (1)McMaster University, (2)United States Geological Survey, (3)University of Guelph

Microplastics (plastic particles ≤5 mm) are a persistent and widespread pollutant in aquatic ecosystems, where they can accumulate in the larvae of aquatic insects inhabiting benthic habitats. Aquatic insects cross aquatic-terrestrial boundaries through metamorphosis, yet few studies have investigated their role in transporting microplastics to terrestrial ecosystems as emergent adults. This study sampled upstream and downstream of eight municipal wastewater treatment plants in the Grand River watershed, Ontario, Canada, in 2022/2023 to assess whether these facilities increase microplastics to aquatic and riparian food webs. Larval and adult caddisflies (Hydropsychidae), mayflies (Heptageniidae), midges (Chironomidae), and riparian spiders (Tetragnathidae) were collected to examine microplastics accumulation, retention through metamorphosis, and cross-ecosystem transfer into riparian spiders. Larval Heptageniidae, adult Chironomidae, and Tetragnathidae exhibited higher microplastic abundances downstream relative to upstream, with concentrations approximately 2.4-, 3.7-, and 2-fold higher, respectively, although the magnitude of differences varied across sites. Organic (cellulose-based) and polyester fibres were the most common, representing ~25-68% and ~16-50% of particles across taxa, respectively. Relationships between microfibre concentration and trophic position ($\delta^{15}N$) were generally weak and site specific, and biomagnification factors were positive from biofilm to each larval taxon and from adult mayflies to spiders. Together, these findings demonstrate that emergent aquatic insects retain and transfer microplastics across aquatic-terrestrial boundaries to riparian predators, with little evidence of trophic magnification. This research addresses a critical knowledge gap by advancing our understanding of microplastic uptake and movement through nearshore food webs via emergent aquatic insects.

Occurrence, Fate and Effects of Contaminants Across Waste and Wastewater Systems

4.22.P-Th214 Monitoring Azole Corrosion Inhibitors in Microelectronics Wastewater by Dansyl Derivatization Followed by Liquid Chromatography With Tandem Mass

Spectrometry

Charles Powley[1], Jessica Anton[1], Justice Woke[1] and Xiaohuan Qin[1] (1)STRIDE Center for PFAS Solutions

Azole compounds, including 1H-1,2,4-triazole, 1-H-pyrazole, benzotriazole, and isomers of tolyltriazole, are widely used as corrosion inhibitors in the microelectronics industry. As semiconductor manufacturing expands in the United States, increasing quantities of these compounds are entering wastewater streams. Because azoles can inhibit the microbial activity essential to biological treatment, many municipal wastewater facilities limit acceptance of influent containing total azole concentrations above 0.01 to 0.05 mg/L. Sensitive and selective analytical methods are therefore needed to monitor these compounds at environmentally and operationally relevant levels.

Although benzotriazole compounds can be measured at low concentrations by liquid chromatography-tandem mass spectrometry (LC-MS/MS) using positive electrospray ionization, pyrazole and triazole compounds remain difficult to analyze because of their high polarity, weak ionization response, and poor chromatographic retention. Across reversed-phase and hydrophilic interaction liquid chromatography (HILIC) methods, these analytes often elute in or near the void volume, and the high salt content of microelectronics wastewaters can further suppress signal and complicate quantitation.

To address these challenges, we developed a chemical derivatization approach in which azoles are coupled with dansyl chloride to improve retention and LC-MS/MS sensitivity, enhanced by stable isotope-labeled analogs for quantitation. The method achieves detection down to 0.01 mg/L, recoveries of 90% to 110% in overspiked quality control samples, and precision of ±5% relative standard deviation. Application of the method to multiple microelectronics wastewaters and environmental water matrices demonstrates its utility for monitoring azoles in complex, high-salinity samples.

4.22.P-Th215 Enhanced Removal of Organic Micropollutants by a Full-Scale Membrane Aerated Biofilm Reactor Upgrade

Narasimman Lakshminarasimman[1], Sondus Jamal[1], Wayne Parker[1], Dominika Celmer-Repin[2], Leslie Bragg[1] and Mark Servos[1] (1)University of Waterloo, (2)Region of Waterloo

Membrane aerated biofilm reactors (MABRs) are increasingly being adopted to intensify wastewater treatment and reduce electricity consumption. MABRs integrate a range of redox conditions with increased biomass residence times in biofilms, and hence, enhanced removal of organic micropollutants (OMPs) is anticipated. Previous reports of OMP fate in MABRs have been limited to lab-scale studies operated under controlled conditions and there is a lack of information on OMP removal in full-scale MABRs operating under dynamic conditions. This study evaluated the removal of OMPs over a range of North American seasonal conditions in a full-scale hybrid MABR system. OMP fate was characterized over a 3 year period in which an existing conventional activated sludge (CAS) process was upgraded to a hybrid MABR-CAS configuration.

The results revealed that the concentration of 65% of the target compounds (13 out of 20) were reduced in the effluent after the upgrade. Plantwide removal efficiencies of highly removable (> 75%) compounds (acetaminophen, ibuprofen, naproxen, triclosan, triclocarban, and norfluoxetine) and the recalcitrant carbamazepine were not impacted by the addition of the MABR process. However, the removal of three

endocrine disruptors (bisphenol A, estrone, and estradiol) improved from moderate (25 to 75%) removal to a high removal. Further, removal of an additional seven pharmaceuticals (gemfibrozil, sulfamethoxazole, trimethoprim, diclofenac, atorvastatin, and its ortho-hydroxy metabolites) improved from poor (< 25%) to moderate or high removal after MABR installation. After the MABR upgrade, it was found that six OMPs exhibited higher removals under warm weather conditions (19.3 ± 1.6°C) compared to cold weather conditions (13 ± 1.2°C). Mass balance analyses on the MABR revealed a broad range of compound-specific responses, such as complete biotransformation (acetaminophen), partial removal (naproxen) and potential generation from conjugates (sulfamethoxazole, carbamazepine).

Overall, long-term monitoring of the full-scale facility revealed that the hybrid MABR configuration enhanced the removal of a number of OMPs that were poorly removed by the CAS process alone. These findings provide critical insights for wastewater practitioners, regulators, and watershed authorities, showing that MABR implementation improved effluent quality that will enhance environmental and public health protection.

4.22.P-Th216 Evidence of Enantioselectivity in Upstream Processes and Wastewater Treatment of Chiral Antidepressants and Their Metabolites

Sondus Jamal[1], Wayne Parker[1], Leslie Bragg[1] and Mark Servos[1] (1)University of Waterloo

Antidepressants are increasingly being detected in the environment due to their increasing use and continuous reintroduction via wastewater outfalls. Venlafaxine (VEN) and fluoxetine (FLX) are chiral anti-depressants prescribed as racemates. Desvenlafaxine (desVEN) and norfluoxetine (NFLX), their active metabolites are also chiral. The enantiospecific behaviour of chiral drugs is well studied in pharmacology but little work has been done regarding their environmental fate and ecotoxicity. The chirality of compounds can have significant ecotoxicological significance since the enantiomers may have different impacts on organisms. This research aims to investigate the enantiospecific behaviour of VEN, desVEN, FLX, and NFLX in municipal wastewaters. Monthly sampling of raw and treated wastewaters from Oct. 2020 to Apr. 2023 was carried out at three wastewater treatment plants. Samples were collected in triplicate and analyzed by LC-MS/MS equipped with a chiral column. The highest total concentrations in both raw and treated wastewater were observed for desVEN followed by VEN, FLX and NFLX across the WWTPs. The enantiomeric fractions were calculated from concentrations of the R and S enantiomers, where EF = 0.5 racemic mixture, < 0.5 R-enriched and > 0.5 S-enriched. In raw wastewaters across the WWTPs, the EF values for VEN, desVEN, FLX and NFLX were 0.38-0.59, 0.2-0.48, 0.58-0.82, and 0.61-0.77 respectively indicating enantioselective upstream processes prior to entering WWTPs. Post treatment, the EF values for VEN, desVEN, FLX, NFLX in the wastewater effluents shifted significantly and ranged from 0.29-0.56, 0.30-0.62, 0.6-0.76, and 0.52-0.81 respectively across WWTPs. Based on mass-based removal efficiencies, the wastewater treatment processes favored 1) the removal of S-VEN over R-VEN at two WWTPs and the reverse at one WWTP, 2) the “apparent generation” of S-desVEN over that of R-desVEN at two WWTPs yet the “apparent generation” of S-desVEN coupled with the removal of R-desVEN at one WWTP, and 3) the removal of the S enantiomers of FLX and NFLX from two WWTPs. VEN and desVEN exhibited distinct patterns of occurrence, enantiomeric distributions, percent removals, and enantioselectivity when compared to FLX and NFLX despite belonging to the same class of pharmaceuticals. Overall, the enantiospecific behavior of these compounds in wastewaters suggests that their chirality should be considered when monitoring and conducting environmental risk assessments.

4.22.P-Th217 PFAS Occurrence and Seasonal Dynamics in a Semi-Enclosed Gulf Coast Estuary Downstream of Municipal Wastewater Treatment Plant Outfalls

Elizabeth DiBona[1], Kerri Ackerly[1], Raegan Osentowski[1], Kathleen Roark[1] and Kristin Nielsen[1] (1)University of Texas Austin

Per- and polyfluoroalkyl substances (PFAS) are persistent, mobile contaminants ubiquitously detected in aquatic systems globally, yet data characterizing their occurrence and fate in estuaries receiving municipal wastewater discharges remain limited along the Gulf Coast, where warm temperatures, high salinity gradients, and proximity to industrial corridors may significantly influence PFAS behavior and accumulation. Municipal wastewater treatment plants (WWTPs) are well-documented PFAS sources to receiving waters, but the degree to which PFAS loads attenuate, partition, and vary seasonally in downstream estuarine environments is poorly understood. To address these gaps, we characterized PFAS occurrence, compound-specific profiles, and partitioning behavior in estuarine water and sediment collected downstream of six WWTP outfalls discharging into Corpus Christi Bay — a semi-enclosed, tidally restricted estuary with long water residence times and a heavily industrialized coastline. Paired water and sediment samples were collected quarterly across multiple seasons alongside concurrent water quality measurements including salinity, dissolved oxygen, pH, temperature, and organic matter to evaluate spatial and temporal variability in PFAS concentrations and environmental drivers of fate and partitioning. Perfluorooctane sulfonic acid (PFOS) dominated aqueous PFAS profiles across all outfall sites, and total PFAS concentrations exhibited pronounced seasonal variability — summer samples displayed both elevated concentrations and greater compound diversity relative to cooler months, potentially reflecting seasonally driven increases in wastewater loading during peak population and tourism periods. Sediment detections were more spatially variable, with PFOS again predominating where detected and site-specific differences suggesting localized influences on accumulation. These findings establish a PFAS baseline for an understudied Gulf Coast estuary, highlight seasonal dynamics relevant to human and ecological exposure assessment, and support data-driven management for coastal communities navigating dynamic PFAS regulations.

4.22.P-Th219 Pharmaceuticals in Aquatic Food Webs Exposed to Municipal Effluents Are Transferred to Riparian Spiders Through Emergent Insects

John Fast[1] and Karen Kidd[1] (1)McMaster University

The presence of pharmaceuticals in surface waters is threatening freshwater resources globally, with effluents from municipal wastewater treatment plants (WWTPs) having been identified as a source even in treated effluents. Pharmaceuticals in WWTP effluents are known to accumulate in larval insects, but data on retention after emergence and transfer to riparian predators remains limited for many taxa. These links between predator and prey in riparian habitats may facilitate the transfer of aquatic contaminants to terrestrial food webs. This study therefore quantified the accumulation of pharmaceuticals in larval and emergent aquatic insects, and riparian spiders, in areas where WWTP effluents are discharged. Biofilm, aquatic larval and adult insects representing multiple feeding strategies and predator-prey relationships, and tetragnathid riparian spiders, were collected over three time points upstream and downstream of eight WWTPs along the Grand River, a heavily urbanized watershed in Southern Ontario, Canada, in the summer of 2022 and 2023. A QuEChERS extraction of composite samples with mass labelled internal standards was used to quantify six classes of pharmaceuticals in biofilm and invertebrate tissues. The anticonvulsant carbamazepine and the anti-inflammatory diclofenac had

the highest detection frequencies across all sample types at 55 and 70%, respectively, while antidepressants fluoxetine and venlafaxine were detected (>80%) in larval caddisflies (Hydropsychidae), mayflies (Heptageniidae), and damselflies (Coenagrionidae), but in fewer than 20% of riparian spider samples. Concentrations in biofilm and larval insects were elevated downstream versus upstream (max 124 and 45 ng/g, n = 4-9), while concentrations in adult insects were lower for all detected pharmaceuticals relative to larvae. Riparian spiders had detection frequencies and concentrations more comparable to larval insects than emergent adults. These findings suggest that larval insects are accumulating pharmaceuticals found in WWTP effluents and contain elevated concentrations of pharmaceuticals in downstream reaches. These results confirm the presence of pharmaceuticals in emergent adults after exposure during larval stages, and highlight the shared risks of effluent bound contaminants between aquatic insects and their terrestrial predators during emergence events.

4.22.P-Th221 Update and Refinement of the HydroWASTE Database To Support Global Modelling of Contaminants in Rivers

Timothée Briand[1], Heloisa Ehalt Macedo[1], Bernhard Lehner[1] and Jim Nicell[1] (1)McGill University

While wastewater treatment plants (WWTPs) act as a critical barrier between anthropogenic wastewater effluents and natural surface waters, they still represent point sources of contamination, as not all substances present in the wastewater can be fully removed. Contaminants of particular concern include pharmaceuticals, household chemicals, PFAS and microplastics. The global HydroWASTE database v1.0 (2022) currently provides researchers with facility and discharge locations of 58,502 WWTPs worldwide, including information on the level of treatment, the population served, and the effluent discharge. With the continued growth of the global population and with an increasing consumption of compounds that result in water contamination, including antibiotics, it becomes crucial to develop model-based global contamination scenarios using the most accurate data available. Since HydroWASTE v1.0 was released, the European Union, Canada and the United States, among many other countries, have published new datasets on WWTPs. To update HydroWASTE, an investigation of public data from various governments, organizations, or through verified OpenStreetMap locations has been performed to integrate new WWTP locations and complement existing information. Missing attributes (i.e., population served, level of treatment, and effluent discharge) are estimated by using similar geospatial methods as for HydroWASTE 1.0, but with more comprehensive supporting datasets. This project will also revise the geospatial allocation of population to specific WWTPs in order to better model the quantity of treated and untreated water released into streams. Updating HydroWASTE with new, more accurate and up-to-date information provides a better inventory of WWTPs worldwide, which in turn will allow for a more realistic modelling of chemicals and an improved understanding of the role of WWTPs as contaminant sources in streams globally.

4.22.P-Th224 PFAS in Game Animal Manures: An Emerging Pathway of Environmental Contamination and Exposure

Markis' Hamilton[1], Wilson Rumbeiha[2] and Aramandla Ramesh[1] (1)Meharry Medical College, (2)University of California Davis (UC Davis)

Per and polyfluoroalkyl substances (PFAS) are human made chemicals found in firefighting foams, consumer products, industrial materials, and contribute to environmental contamination. These compounds are persistent,

resist environmental degradation, and have the potential to bioaccumulate in organisms. Game animals can be exposed to PFAS through contaminated water, soil, vegetation, and food sources within their habitats. The presence of PFAS in scats may facilitate the introduction of these contaminants into soil environments when scat is used as a manure in organic agricultural operations. This creates a potential pathway for PFAS to be introduced and recycled into soil systems. This study examined the presence of PFAS in manure samples collected from game animal species such as deer, moose, elk, mule deer, bison, wild boar, black bear, quail, duck, turkey, and rabbit.

The collected manure samples were processed and extracted using a combination of methanol: acetonitrile, followed by solid-phase extraction (SPE) cleanup to isolate PFAS compounds from the complex matrices. Subsequently, the samples were analyzed using liquid chromatography-tandem mass spectrometry (LC-MS/MS), adopting the EPA Method 1633. The ΣPFAS concentrations in manures ranged from 11 to 1399 ng/g dry weight. PFAS concentrations varied substantially among manure types, indicating differences in PFAS burden across animal manure sources. Across the manure samples, PFAS profiles included both short chain and longer chain compounds, with short chain PFAS such as PFBA, PFBS, PFHxA, PFHpA, and PFPeA appearing more frequently and longer chain compounds such as PFOA, PFOS, PFHxS, and PFNA occurring at lower levels.

Overall, these findings support game animal manure as a potential environmental source of PFAS when applied to soil as a natural fertilizer and may contribute to soil distribution, crop uptake, and dietary exposure of humans. Detection of PFAS in game animal manure suggests that these chemicals are moving through wildlife and may contribute to exposure pathways involving contaminated soil, water, and fertilizer applied to farmland. These findings highlight the need for broader monitoring of manure used in organic farming practices. Additionally, scat could serve as sentinel for monitoring environmental contamination and offering insights into potential mobility, bioaccumulation and assessing risk from PFAS exposures.

Disclaimer/Disclosure: This work was supported by DOE grants DE-EM0005266 and DOE-BSRA G-SOW-A-02557, NIH grants LUH3HG013248-02, R25GM160671, and GM151274.

4.22.P-Th225 Occurrence and Distribution of Contaminants in Biosolids From Wastewater Treatment Works Across the Southwest UK

Stephanie Andrews[1], Paul Boisseaux[1], Lukas Smik[1], Ceri Lewis[1] and Tamara Galloway[1] (1)University of Exeter

Approximately 4 million tonnes of biosolid are spread to agricultural land in the UK, accounting for 75 % of total annual production. These biosolids provide a high nutrient and organic fertilizer to farmers, preventing incineration of waste, and providing financial income to water companies. To ensure the safety of the environment, biosolids in the UK are subject to the Safe Sludge Matrix and Sludge Regulations in agriculture, ensuring metals, nitrates and phosphates remain within defined safe limits, however microplastics are not categorized within these regulations as no safety threshold has been established. To understand and assess the risk of contaminants (Microplastics, Metals and Organic Chemicals) in biosolids to the environment, the occurrence and fate of these must be established. Samples of Anaerobic digest and Lime stabilised biosolid end-product from 10 Wastewater Treatment Works were taken from across the Southwest region of the UK, with five sequential samples taken over time intervals with a minimum of a one-week period between. Samples were analysed for microplastics, heavy metals, and organic chemical contents. Data presented will show the abundance and distribution of these contaminants and will assess if sludge treatment, site demographics or

location have any correlation with the trends observed in samples.

4.22.P-Th226 Extractable and Leachable PFAS From Spent Granular Activated Carbon in Landfill Leachate Treatment Plants

Akihiro HARA[1], Junko Ono[1], Rina Adachi[1], Arisa Banno[1], Koji Ito[1], Hidenori Matsukami[2], Kazuto Endo[2] and Yoshinori Yabuki[1] (1)Research Institute of Environment, Agriculture and Fisheries, Osaka Prefecture, (2)National Institute for Environmental Studies (NIES)

PFAS (Per- and polyfluoroalkyl substances) are frequently detected in landfill leachate due to their widespread use and subsequent disposal in landfills. Granular activated carbon (GAC) has been widely applied as an advanced treatment process for landfill leachate. Although GAC filtration in landfill leachate treatment plants is not primarily designed for PFAS removal, substantial PFAS removal in this process has been reported. For the application of GAC treatment to PFAS removal, the leachability of PFAS from spent GAC samples should be investigated in terms of environmental impact and waste disposal.
The objective of this study was to evaluate both extractable and leachable PFAS in spent GAC collected from landfill leachate treatment plants. In addition, the relationship between PFAS amounts and their properties was investigated.
Ten spent GAC samples were collected from 10 landfill leachate treatment plants. To evaluate PFAS leaching behavior, extractable and leachable PFAS were measured, and leaching ratios were calculated (leachable amount/extractable amount). Extractable PFAS were evaluated using a modified extraction procedure using methanol-based organic solvents based on a Japanese draft extraction method. In addition, leaching tests using ultrapure water were conducted under fixed conditions. PFAS concentrations were determined by LC–MS/MS targeting 34 compounds.
Although multiple PFAS such as PFOA, PFHxA, PFPeA, PFBS, and GenX were extracted from spent GAC samples, the leachable PFAS amounts did not correspond to extractable amounts for several reasons. PFAS, with lower distribution coefficients (log D) tended to show higher leaching ratios. In addition, PFAS with high extractable amounts tended to exhibit high leachable amounts, indicating that the absolute amount of PFAS in GAC influenced the extent of leaching. On the other hand, a significant difference in leaching ratios was observed among GAC samples, despite the extractable PFAS amounts in GAC were roughly the same.

These results suggest that PFAS properties may explain part of the observed leaching behavior. High leachable PFAS amounts could also result from high PFAS amounts in GAC samples. Since water quality, GAC type, and GAC replacement frequency differed among the treatment plants where GAC samples were collected, factors other than PFAS properties should also be investigated.

Disclaimer/Disclosure: This research was supported by the Environment Research and Technology Development Fund (JPMEERF20233003 and JPMEERF20263003) of the Environmental Restoration and Conservation Agency, Ministry of the Environment, Japan, and by JSPS KAKENHI Grant Number JP25K15497.

4.22.P-Th227 Organofluorines Beyond PFAS: Biodegradation of Pharmaceuticals and Pesticides

Laurinda Nyarko[1], Tais Souza[1], William Pomerantz[1], William Arnold[1] and Sebastian Behrens[1] (1)University of Minnesota

The environmental fate of organofluorine compounds from wastewater systems, including their biodegradation pathways and transformation products, remains poorly understood. While per- and polyfluoroalkyl substances (PFAS) have gained considerable attention due to their widespread application, others like fluorinated pharmaceuticals and pesticides which contribute significantly to total organofluorine loads, are comparatively understudied.

Biodegradation studies were conducted with aerobic activated sludge microbial cultures on model compounds with carbon-fluorine (C-F) groups and core ring structures common in fluorinated pharmaceuticals and pesticides, 4-fluorophenol (FP), 3-trifluoromethylphenol (TFMP), 4-trifluoromethylbenzoic acid (TFMB), and 6-trifluoromethylnicotinc acid (TFMN), to identify fluorinated structures that undergo complete biodegradation and those that persist. A highly sensitive coumarin-based fluorescence assay was developed for rapid and high throughput quantification of fluoride release. Fluoride measurements were paired with monitoring of parent-compound loss using liquid chromatography (LC) with UV detection to distinguish compounds mineralization from biotransformation into persistent fluorinated byproducts.

The results showed complete degradation of FP with stoichiometric fluoride release whereas TFMP was only partially degraded and defluorinated, indicating the formation of fluorinated byproducts. Fluoride ion-selective electrode data further validated the accuracy of the fluorescence assay measurements. In contrast to the fluorinated phenols, TFMB and TFMN did not degrade, suggesting that these compounds are more persistent and that differences in core ring structures and C-F bond types strongly influence degradation pathways. Current research is extending this experimental and analytical approach to commercial fluorinated pharmaceuticals, fluoxetine and 5-fluorouaracil. Additional work aims to elucidate differences in biodegradation pathways. These studies will advance understanding of the fate and environmental impacts of organofluorines, beyond PFAS, in wastewater systems and support remediation strategies.

Disclaimer/Disclosure: This project is funded by Minnesota Environment and Natural Resources Trust Fund.

4.22.P-Th228 Buying Your Problems: Reclaimed Water Use as a Cause of Effluent Toxicity

Konrad Kulacki[1] and William Goodfellow[1] (1)Exponent

Industrial operations can have high water demand, which can be expensive as well as depress local water resources (e.g., groundwater, surface water). One alternative to using these water sources is the use of reclaimed water from municipal wastewater treatment facilities, i.e., water that has been previously used, treated, and is ready for discharge. However, use of this alternative source of water may pose challenges to discharge compliance requirements. Here, we report on a series of studies undertaken to ascertain the source of intermittent chronic effluent toxicity at a manufacturing facility using reclaimed water as a part of its process makeup water. Simulated effluent mixture experiments and a whole facility reclaimed water trial both indicated that facility effluent toxicity was due in large part to the use of reclaimed water. Ultimately, the costs of using reclaimed water and any associated effluent toxicity issues must be weighed against the benefits of not using

groundwater or surface water as process water, as well as the overall management objectives for receiving waters.

4.22.P-Th229 Modelling Multi-Contaminant Risks in Surface Waters From Different Sources and Across Scales

Heloisa Ehalt Macedo[1], Bernhard Lehner[1], Jim Nicell[1], Wibke Busch[2] and Liza-Marie Beckers[3] (1)McGill University, (2)Helmholtz Centre for Environmental Research (UFZ), (3)German Federal Institute of Hydrology (BfG)

Chemical pollution in surface waters remains a significant yet unevenly characterized driver of impacts at the human–animal–environment interface, particularly at regional to global scales. Monitoring and risk assessment are often constrained by limited data coverage, heterogeneous reporting, and computational complexity. In this talk, I present applications of HydroFATE, a global contaminant fate model developed to simulate chemical concentrations and associated risks across river systems worldwide.

HydroFATE integrates large-scale geospatial datasets, wastewater treatment plants as point sources, untreated wastewaters as diffuse sources, chemical-specific properties, and downstream transport and attenuation processes to estimate exposure and risk to aquatic ecosystems and downstream human populations. Framed within a One Health perspective, the model is applied to a series of collaborative case studies, including: (1) a global risk assessment of antibiotics in surface waters; (2) a regional evaluation of the environmental risks associated with 80 chemicals representative of typical wastewater mixtures in European rivers; and (3) ongoing efforts to estimate veterinary antibiotic emissions and fate in Canadian river systems.

Despite the scale and heterogeneity of these applications, HydroFATE retains its core function as a streamlined screening and prioritisation tool. The results identify spatial hotspots, dominant emission pathways, key data gaps, and methodological challenges inherent to large-scale chemical fate modelling, while also highlighting opportunities for model refinement and integration with complementary approaches. By advancing a data-driven, policy-relevant framework for contaminant fate assessment, this work aims to support efforts to improve protection of freshwater ecosystems and human health from chemical pollution within a One Health context.

4.22.P-Th230 Applying Advances in Point-Source Chemical Fate and Transport Models To Evaluate National Pollutant Release Inventory (NPRI) Emissions (Including PFAS) to Water

Liisa Toose[1], Alessandro Sangion[1], Jon Arnot[1] and Alicia Berthiaume[2] (1)Arnot Research & Consulting (ARC), (2)Science & Technology Branch, Environment and Climate Change Canada

The National Pollutant Release Inventory (NPRI), established under CEPA 1999, is a publicly accessible database that tracks releases and transfers of pollutants across Canada. These quantitative estimates for facility-specific chemical emissions are often used as surrogates for information regarding the potential exposure to substances, and by extension, estimating risk. However, in addition to the chemical release rate and frequency, exposure is a function of chemical properties (e.g., partition ratios, degradation half-lives), fate and transport process under various environmental conditions, environmental concentrations, exposure pathways, species-specific exposure factors and bioaccumulation. The Risk Assessment and Identification and Ranking (RAIDAR) regional-scale model has been used to rapidly screen large numbers of chemicals (Domestic Substances List, NPRI). Here, we describe a screening-level point-source (PS) multi-media model based on the

RAIDAR framework (RAIDAR-PS) that can be parameterized to different locations. RAIDAR-PS is used to integrate NPRI release data with chemical property data built into the EAS-E Suite platform to estimate exposure and risk for 177 organic chemicals on the NPRI (2014-2024). Emission factors (EFs) were prescribed to each chemical based on NPRI release description, physical-chemical properties; for transfers to wastewater treatment plants (WWTP), EFs were estimated using the EAS-E Suite WWTP model. Abiotic and biotic exposure concentrations were predicted for existing NPRI releases to water. A case study highlights the prediction and evaluation of bioaccumulation factors (BAFs) for various PFAS and 2,3,7,8-TCDD showing good agreement with measured literature values. This work highlights the capacity for improving screening-level local-scale risk assessments for NPRI chemicals. Future enhancements should include site-specific hydrology, spatial river segmentation, temporal variability in emissions, and incorporation of toxicity thresholds and new approach methodologies (NAMs) to further advance risk-based screening and priority setting.

4.22.P-Th231 PFAS in Canadian Municipal Wastewater Treatment Systems: Dominance of Ultrashort-Chain PFAS, Application of the TOP Assay, and Time Trends Between 2009 and 2024

Sarah Gewurtz[1], Steven Teslic[2], Bharat Chandramouli[3] and Shirley Anne Smyth[2] (1)Environment and Climate Change Canada (ECCC), (2)Environment and Climate Change Canada, (3)SGS AXYS Analytical Services Ltd.

Environment and Climate Change Canada's (ECCC) wastewater monitoring program was initiated in 2008 to monitor concentrations of chemical substances in wastewater systems in order to examine their potential as environmental exposure pathways in support of risk assessment and risk management activities. We have collected samples from over 80 wastewater treatment plants (WWTPs) across Canada which have been analyzed for a multitude of substances including per- and polyfluoroalkyl substances (PFAS). We previously analyzed up to 40 PFAS with targeted methods based on United States Environmental Protection Agency (USEPA) Method 1633. The first objective of this current study was to better characterize the total PFAS present in the wastewater samples through analysis of ultrashort-chain PFAS in effluent and the total oxidizable precursor (TOP) assay in effluent and biosolids. The second objective was to assess time trends of PFAS concentrations in influent, effluent, and biosolids measured between 2009 to 2024. Elevated concentrations of some ultrashort-chain PFAS were observed. One ultrashort-chain PFAS, trifluoroacetic acid, was detected in 100% of effluent samples with a median concentration of 1,265 ng/L, which is over two orders of magnitude greater than the highest median concentration of the short- and long-chain PFAS in these samples. Two other ultrashort-chain PFAS, pentafluoropropionic acid and trifluoromethanesulfonic acid were detected in less than half the samples; however, their maximum concentrations in effluent of 3,360 and 379 ng/L were more than 10- and three-fold higher than the maximum concentrations of the short- and long-chain PFAS. PFAS concentrations in biosolids that underwent the TOP assay were between 2.3 and 12-fold higher than untreated samples. However, the PFAS concentrations in effluent that underwent the TOP assay were more comparable to untreated samples, likely due to transformation of PFAS precursors to measurable PFAS during wastewater treatment. The time trends of most long chain-PFAS decreased over time in Canadian wastewater media between 2009-2024, reflecting regulatory action and industrial phase-outs. Although concentrations of short-chain PFAS increased between 2009 and 2021, recent data suggest their concentrations have decreased between 2021 and 2024 which correspond with recent activities to address the class of PFAS. However, additional data are needed to establish a definitive trend.

4.22.P-Th232 Legacy Sewage Effluent Signatures in the Sediments of San Pedro Basin, California

Jacob Schmidt[1], Mong Sin Christine Wu[1] and David Valentine[1] (1)University of California Santa Barbara (UC Santa Barbara)

The Southern California Bight was polluted throughout the 20th century from a combination of sewage effluent discharge and deep ocean disposal of industrial wastes. Pollution hotspots persist in sediments of shallow coastal shelves and deeper (>800 m water depth) coastal basins, particularly near the Los Angeles metropolitan area. Recent work in our group revealed concerning concentrations of pesticide DDT in sediments in and around San Pedro Basin, directly offshore Los Angeles, that resulted from surface ocean discharge of DDT manufacturing wastes from 1947-1961. However, spatial and temporal patterns in DDT metabolite concentrations suggested some additional input from a Los Angeles County sewage outfall on the adjacent shallow Palos Verdes Shelf. In this work, we investigated whether a similar spatial and temporal pattern exists in the organic carbon content of San Pedro Basin sediments, which would support the hypothesis of organic-rich Los Angeles County sewage effluent flux into the basin throughout the 20th century. Sediment depth resolved total organic carbon and total nitrogen were determined by elemental analysis for 43 sample locations covering a 719 sq. km. footprint of San Pedro Basin. Using this data, anthropogenic organic carbon (AOC) was estimated as the fraction of carbon deposited from sewage effluent flux into the basin using an end member mixing model for C:N values across sample location and depth. A hotspot of elevated AOC was observed in sediments of northeast San Pedro Basin, nearest to the Los Angeles County sewage outfall pipes. Additionally, peak AOC deposition occurred during the 1960s and 1970s, coincident with peak discharge of total suspended solids prior to the onset of advanced primary waste treatment. The timing of peak AOC in the basin also matched that of DDE, a DDT metabolite suspected of being transported offshore from the Palos Verdes Shelf or sewage outfall pipes. The spatial and temporal deposition patterns of AOC in San Pedro Basin suggest contaminants do enter the deeper San Pedro Basin from the Palos Verdes Shelf. This mechanism implies adverse ecological effects from pollutant-laden effluent may extend further offshore than previously thought. Further, the substantial preservation of AOC in San Pedro Basin sediments (up to 30% of total organic carbon in sediment dated to c.1970) has important implications for marine-based carbon sequestration efforts aimed at combating global climate change.

4.22.P-Th233 Conventional Treatment for PFAS Removal: Insights Into Long- and Short-Chain PFAS Interactions With Different Coagulants and Flocculants

Krishnaveni Kannan[1], Shamsunnahar Suchana[1], Mathieu Verhille[2], Mathieu Lapointe[2] and Nathalie Tufenkji[1] (1)Department of Chemical Engineering, McGill University, Quebec, Canada, H3A 0C5, (2)Department of Construction Engineering, École de technologie supérieure, Québec, Canada, H3C 1K3

Conventional physicochemical water treatment methods, such as coagulation and flocculation, are widely used to treat municipal wastewater because of their low cost and operational simplicity; however, these methods are generally less effective at removing persistent organic micropollutants, such as per- and polyfluoroalkyl substances (PFAS). The interaction of PFAS compounds with coagulants and flocculants during treatment influences both removal performance and the environmental transport of PFAS through sludge, which is often used as biosolids for agricultural applications or disposed of in landfills. The chemical properties of PFAS compounds, including functional group and chain length, play a major role in their interactions with metal ions

and polymers used during coagulation and flocculation. However, systematic studies evaluating the role of coagulants and flocculants in PFAS partitioning from water remain scarce. This study systematically examined how coagula formed by different coagulants and flocs formed through combined coagulation–flocculation treatment influence the adsorption behavior of six PFAS compounds and the mechanisms governing their partitioning during treatment. The study also investigated the impact of prolonged flocculation on the repartitioning behavior of sludge-bound PFAS into the aqueous phase. The findings demonstrate that coagulants are the primary drivers of PFAS removal, with short chain PFAS showing negligible removal, whereas flocculants mainly promote floc bridging and settling. The study also found that long and short chain PFAS exhibited increased adsorption onto preformed coagula and flocs, implying that the original constituents in source water affect PFAS removal during conventional treatment. These results provide insights into the interactions between PFAS and different coagulant–flocculant combinations. Overall, this work highlights the need for enhanced coagulation techniques using novel materials that can effectively target both long- and short-chain PFAS to reduce their transport through wastewater systems and into environmental matrices.

4.22.P-Th234 Characterizing the Occurrence and Transport of Cattle Feedlot-Associated Contaminants in Catch Basins, Air Particulate Matter, and Impacted Surface Waters

Jonathan Challis[1], Tara Vucurevich[1], Tara Shelton[1] and Ilakkiya Thirugnanasambandam[1] (1)Agriculture and Agri-Food Canada (AAFC)

A survey of agricultural- and feedlot-impacted waters was conducted in Southern Alberta from 2022-2025 to identify and quantify the presence of the parasiticides ivermectin, fenbendazole, and oxfendazole, the antibiotic monensin, and the beta-agonist ractopamine. Grab samples were collected six times per year at five sites throughout Frank Lake and it's downstream wetland system, which receives municipal and industrial effluents. Over this same time period, continuous passive sampling was conducted from May to October at five sites throughout the Old Man River watershed, an area of Southern Alberta with a high density of CAFO's. Across all sites and sample types, oxfendazole, a major metabolite of fenbendazole, was detected with greatest frequency (35%), followed by monensin (21%), fenbendazole (15%), and ractopamine (4%). Generally concentrations were low, with >90% of measured concentrations falling below 50 ng/L. Oxfendazole and monensin concentrations were greatest, with MECs ranging from 400 to 1200 ng/L. Most detections were observed at sites in close proximity to livestock feedlots and those in the Frank Lake system receiving effluent inputs.

Medium volume portable air samplers were deployed around cattle feedlots to assess transport of the target chemicals in particulate matter (PM2.5, PM10, and Total PM). Maximum PM concentrations ranged from 10 – 25 µg/g of fenbendazole and monensin, while concentrations of oxfendazole and ractopamine were lower, ranging from 0.05 – 3 µg/g. Ivermectin was not detected. Based on estimates of PM emissions from typical commercial feedlots in Southern Alberta (10,000 head), gram quantities of these chemicals are transported off-feedlot per day. Catch basin water samples at the same commercial feedlot where air sampling took place measured concentrations of monensin and ractopamine ranging from 200 – 7000 ng/L. Fenbendazole, oxfendazole, and ivermectin were not detected in any catch basin samples. This work provides important monitoring data needed to improve our understanding of the occurrence and transport mechanisms of these compounds and to facilitate appropriate risk assessment and management of these veterinary-use pharmaceuticals.

4.22.P-Th235 Role of Suspended Particles in the Long-Range Transport of Cyclic Volatile Methylsiloxanes in a Canadian River

Jaeshin Kim[1] and Jingyun Ye[1] (1)Dow Chemical Company

Cyclic volatile methylsiloxanes (cVMS) are widely used industrial and consumer chemicals whose environmental fate and long-range transport potential (LRTP) continue to be evaluated to support scientific understanding and regulatory assessment. In this study, a Python-based, multi-box implementation of the Quantitative Water–Air–Sediment Interaction (QWASI) model was developed and applied to investigate the fate and transport of octamethylcyclotetrasiloxane (D4), decamethylcyclopentasiloxane (D5), and dodecamethylcyclohexasiloxane (D6) in the North Saskatchewan River, Canada. The model explicitly represents advective transport, intermedia mass transfer, degradation, and particle-mediated sediment processes along a spatially discretized river reach downstream of a major wastewater effluent source in Edmonton, Canada.

Results reveal distinct compound-specific transport behaviors driven by differences in volatility and particle sorption affinity as well as degradation in water. D4 transport is dominated by volatilization, resulting in the longest characteristic travel distance (CTD), on the order of <200 km, whereas D6 is rapidly removed from the water column via particle-mediated burial, yielding the shortest CTD, on the order of ~100 km. Sensitivity analyses demonstrate that hydrodynamics and volatility primarily control D4 transport, whereas particle-related parameters, including particle concentration, organic carbon content, mass transfer coefficients, and particle density, strongly influence the transport of D5 and D6. These findings provide mechanistic insight into the aquatic long-range transport potential of cVMS and support scientific and regulatory screening assessments of the LRTP of cVMS.

4.22.P-Th236 Disentangling the Effects of Biosolid Legacy, Soil Type, and Soil Microbial Dynamics on Biochar-Mediated Reduction of PFAS Accumulation in Soybean

Sumantee Baidya[1], Fariba Rostami[1] and Wayne Omagamre[1] (1)University of Maryland Eastern Shore

Land application of biosolids is an important nutrient-management practice but also a major pathway for introducing per- and polyfluoroalkyl substances (PFAS) into agricultural soils. Although PFAS uptake by crops has been documented, the relative importance of biosolid application history, soil type, soil microbial communities, and management interventions in controlling PFAS accumulation under field conditions remains poorly understood. This study investigates factors governing PFAS transfer from biosolid-amended soils into soybean (Glycine max) grown under commercial field conditions in Maryland. Experimental microplots were established at two agricultural sites with contrasting biosolid histories, including a field receiving a single biosolid application within the previous five years and a field receiving repeated biosolid applications over approximately 30 years. Multiple soil types were represented across sites, including IgB, HcA, and WdcA soils. Preliminary soil characterization revealed substantially higher PFAS concentrations and a broader suite of detectable compounds in the long-term biosolid field relative to the recently amended field. Long-chain PFAS, including PFOS, PFDA, PFUnA, PFDoA, PFDS, and PFTeDA, were particularly enriched in historically amended soils. Soybean was grown under biochar-amended and unamended conditions, with selected treatments also receiving the nitrification inhibitor 3,4-dimethylpyrazole phosphate (DMPP). Plant growth, chlorophyll content, tissue PFAS concentrations, soil physicochemical properties, and soil microbial diversity are being evaluated throughout the growing season. Microbial community composition is being characterized at

the beginning, midpoint, and conclusion of the experiment to determine whether shifts in microbial communities are associated with PFAS availability and crop accumulation. A complementary greenhouse study is evaluating the same management factors under controlled conditions while incorporating root transcriptomic analyses to identify molecular pathways associated with PFAS uptake and stress responses. Together, these studies evaluate whether biosolid legacy explains baseline PFAS burden, whether soil type influences PFAS mobility and plant uptake, and whether biochar and DMPP treatments alter PFAS accumulation through changes in sorption, nutrient cycling, microbial community dynamics, or plant physiology. Results from all components of the study will be presented.

Disclaimer/Disclosure: The study is supported by a grant from the Harry R. Hughes Center for Agro-Ecology. The views expressed do not necessarily reflect the official policies of the center

4.22.P-Th237 Community-Customized Predictions of Pharmaceutical Influent Concentrations and Removal Mechanisms in Water Reuse Treatment Trains

Vanessa Maybruck[1], Akhila Annireddy[2], Dinuka Hannadige[1], Minh Nguyen[2], Alfonso Bastias[1] and Cresten Mansfeldt[1] (1)University of Colorado Boulder, (2)University of Colorado Boulder (May 2026 graduate)

A key challenge to implementing water reuse in the United States is the removal of contaminants sufficiently to meet direct potable water reuse (DPR) regulations. Pharmaceuticals are directly regulated or are candidates for DPR regulation in the states of Colorado, California, and Arizona, and more states are expected to follow this precedent. Therefore, decision support tools for monitoring and treating pharmaceuticals in reuse waters are needed. The SeweRx tool addresses this need by providing community-customized pharmaceutical concentration profiles in wastewater influent and treatment mechanisms for their removal. To do this, SeweRx combines a comprehensive database containing over 200 pharmaceuticals (PharmUse) with three modeling approaches (PharmFlush, PharmShed, and PharmTreat). This presentation will focus on the PharmShed and PharmTreat modules. PharmShed is an ensemble, multi-class classification model that predicts pharmaceutical wastewater influent concentrations for a community from its demographic characteristics. PharmShed provides enhanced granularity in its predictions and is likely to improve compliance with DPR regulations for a given facility. Additionally, this model is expected to demonstrate significant differences between communities with different demographics, with community age structure and household income distributions hypothesized to have the largest impact on wastewater pharmaceutical concentrations. PharmTreat uses an unsupervised machine learning approach to predict pharmaceutical removal mechanisms in water reuse treatment trains from pharmaceuticals' functional groups. PharmTreat is expected to identify at least one viable removal mechanism for each of over 200 pharmaceuticals. This will provide a foundational study for the bench-scale and pilot-scale testing of the removal of pharmaceuticals for which the treatment mechanism(s) was previously unknown. Notably, all four modules of SeweRx are fully integrated into a free web application that was designed with feedback from water reuse professionals for maximum utility. Overall, SeweRx provides a comprehensive and community-customized decision support tool for both monitoring and treatment of over 200 commonly-used pharmaceuticals in water reuse treatment trains.

Disclaimer/Disclosure: This work is supported by an NSF NRT Integrated Data Science Fellowship (award number 2022138, University of Colorado Boulder BioFrontiers Institute), an NSF GRFP fellowship (award

number DGE 2040434), and an NSF CAREER grant (award number 2542554). All findings/opinions are the authors'.

Pesticides in the Aquatic and Terrestrial Environment: Monitoring, Fate, Exposure and Ecological Effects

4.23.T-01 What's in the Margins? The Impacts of Insecticides on Cropland Songbird Communities

Anastasia Cornea[1], Sonia Cabezas Ruiz[1] and Christy Morrissey[1] (1)University of Saskatchewan

Agricultural intensification in the Canadian Prairies has led to heavy reliance on insecticides and other chemical inputs. Neonicotinoids, the most widely used insecticide globally, can cause birds to experience adverse neurological, reproductive, and physiological effects and are associated with the dramatic decline in grassland bird populations in North America. In prairie cropland ecosystems, remnant non-crop vegetation is often the only habitat for birds to breed and forage in. Many species of songbirds inhabit these areas, but the effects of living in small patches within proximity to industrial agriculture is not known. It is possible that non-crop vegetation acts as an ecological trap, drawing in birds to low quality/high hazard habitats. We hypothesized that non-crop vegetation offers a refuge to breeding birds, but characteristics of the non-crop patch may decrease fitness through pesticide exposure and reduction/alteration of food supply. Through blood plasma insecticide analysis of samples collected from 9 target species of common farmland songbirds breeding in non-crop vegetation at 8 cropland sites across Saskatchewan, we compared the concentrations of insecticides and their analytes. We also measured insect sub-lethal exposure to insecticides through analysis of sweep samples in both crop and non-crop areas at each site. Through GIS tools we categorized the proportion of land around the sample collection sites (crop type, grass, shrub, wood, wetland, or forage mix) and collected information on total non-crop patch area and perimeter: edge ratio. Neonicotinoids, clothianidin and thiamethoxam were frequently detected in blood in all target species and sites, with the highest concentrations in Clay coloured sparrows, Red winged blackbirds, and Vesper sparrows. Conversion of marginal lands to non-crop vegetation has the potential to increase agricultural efficiency and increase available habitat for avian wildlife but understanding the hidden risks and how to mitigate them is crucial for effective conservation planning.

4.23.T-02 Pesticide Exposure and Risk Estimation for Watersheds: A Bayesian Approach for Combining Models and Monitoring

Jannicke Moe[1], Anders L. Madsen[2], Sophie Mentzel[3], Merete Grung[3], Samantha Martins[3], Luka Snoj[4], Gašper Šubelj[4], Frederik Verdonck[5], Karel Vlaeminck[5] and Karel Viaene[5] (1)Norwegian Institue for Water Research (NIVA), (2)HUGIN EXPERT, (3)Norwegian Institute for Water Research (NIVA), (4)TC Vode, (5)ARCHE Consulting

A suite of process-based models are available for predicting the environmental release, transport, fate and exposure of chemical substances and mixtures in the aquatic environment. However, even advanced models do not always make optimal use of the latest scientific techniques or relevant available datasets. Within the project ENCORE (ENvironmental CO-exposure and Risk Estimation, 2024–2026) we have developed a probabilistic framework for predicting exposure and risk of chemical mixtures to aquatic ecosystems at the watershed scale

across Europe. This approach synthesizes diverse information—chemical use, transport, degradation, fate, and hazard—while explicitly accounting for uncertainty in exposure data. Our starting point is the European-scale process-based chemical fate model from the former EU project SOLUTIONS. The ENCORE fate model is a further developed and refined version, including new information on chemical use and emission. To further leverage the ENCORE fate model output, we make use of pesticide monitoring data from the European Environment Agency's Water Information System for Europe (Waterbase - Water quality), which contains observations of pesticides and other hazardous substances from more than 50 million samples across Europe. To this end, we have developed an object-oriented Bayesian network (BN) model representing the main properties and outputs of the ENCORE fate model, expressed as discrete probability distributions. This BN allows us to explore the use of Bayesian updating techniques at different levels of spatial aggregation, for different purposes such as: (1) River Basin District level - BN model exploration: evaluation of approach. (2) Water body level - refined BN model predictions: Bayesian inference for improved accuracy of exposure characterisation at higher spatial resolution. (3) Monitoring site level - parameter learning: Bayesian parameter learning for refined BN model settings (conditional probability tables). The probabilistic exposure characterisation is combined with environmental threshold values to derive probabilistic risk quotients for individual pesticides and for mixtures. This presentation will focus on results from a case study with selected pesticides in Belgium, as a proof-of-concept.

Disclaimer/Disclosure: The ENCORE project is sponsored by the European Chemical Industry Council (CEFIC) as part of the Long Range Initiative (LRI) under project ECO-66 “Next generation risk assessment methods supporting the identification of environmental co-exposures of potential concern”.

4.23.T-03 Effectiveness of Application Setbacks for Pesticide Runoff Mitigation in Prairie Pothole Agricultural Systems: A Three-Year Field Study

Sarah Crawford[1], Cameron Harrington[1], Darian Blanchard[2], Laura Jefferies[1] and Erin McGregor[1]
(1)Syngenta, (2)Syngenta Crop Protection AG

A three-year field study was conducted in the Canadian Prairie Pothole Region to assess agricultural pesticide runoff patterns and evaluate mitigation strategies, specifically focusing on application setbacks near wetlands. The study examined two actively farmed agricultural fields with adjacent downslope wetlands, investigating five different pesticide chemistries under typical prairie agricultural practices. The experimental design included controlled irrigation events 48 hours post-application, simulating worst-case 1-in-5 year rainfall scenarios on average field slopes of 5 and 7% to evaluate maximum runoff potential. Sampling locations were strategically positioned at in-field, edge-of-application, 5 m and 10 m setback distances from edge of application, and within wetland areas using runoff bucket collectors, grab samples and daily autosamples from constructed limnocorrals. Comprehensive monitoring included water, soil and sediment analysis, as well as measurement of environmental quality parameters. Study design was progressively refined over the three-year period, with the final year implementing the most robust sampling and field methodology. Results demonstrated that wetland water samples consistently showed pesticide concentrations near or below limits of detection (LOD) throughout the study season (June-October). A general concentration gradient was observed, with significant decreases from in-field measurements to edge of application, and further reductions at 5 m and 10 m setbacks, where concentrations typically approached LOD. The study indicates that generally 5 m setbacks from edge of application can effectively mitigate pesticide runoff in prairie agricultural systems, potentially offering a more

implementable solution for agricultural producers while maintaining environmental protection. These findings suggest that edge-of-application setbacks may provide a practical alternative mitigation options for agricultural producers in western Canada compared to traditional edge-of-wetland vegetative filter strips, which are challenged by seasonal and annual wetland boundary variations and maintenance considerations.

4.23.T-04 Long-Term Trends of Pyrethroid-Driven Toxicity and Its Relationship With Land Use in California Watersheds

Bushra Khan[1], Bryn Phillips[1], Tessa Fojut[2] and Ronald Tjeerdema[3] (1)University of California Davis (UC Davis), (2)California State Water Resources Control Board, (3)No Affiliation

The Stream Pollution Trends Monitoring Program (SPoT) is a statewide program of the California State Water Resources Control Board and provides critical information about sediment contamination and toxicity at 90 sites across diverse watersheds. Under California's Surface Water Ambient Monitoring Program (SWAMP), SPoT has identified long-term trends for various contaminants since 2008. One of the most notable findings of this program is pyrethroid trends and their relationships with land use and toxicity. Sediment samples collected annually between 2010 and 2022 were analyzed for pyrethroids and tested for toxicity using the amphipod, Hyalella azteca. Pyrethroid toxic units (TUs) were calculated, and trends were analyzed using Mann-Kendall tests. Watershed delineations and land cover data were extracted to identify linkages between pyrethroids, observed toxicity, and land use. Significant relationships between standard toxicity test results and pyrethroid toxic units were identified. Out of eight measured pyrethroid pesticides, bifenthrin accounted for about 50% of the calculated toxic units, and its concentration significantly increased at nearly 25% of SPoT monitoring sites. Decreased amphipod survival was significantly associated with urban land use, as were elevated concentrations of pyrethroids. Based on amphipod survival data, 72% of toxic samples had more than one pyrethroid toxic unit indicating pyrethroid-driven toxicity. Diagnostic testing at an environmentally relevant temperature provided further evidence for pyrethroid contributions to observed toxicity. Pyrethroids continue to be monitored for the program and annual toxicity threshold exceedances are measured to determine areas of concern. These long-term monitoring data inform state agencies and managers about contaminant relationships with waterbody impairments and facilitate management actions.

4.23.T-05 National Scale Assessment of Pesticides in Milkweed

Michelle Hladik[1], Dana Kolpin[1], Carrie Givens[1], Laura Hubbard[1], Rachael Lane[1], Jason Masoner[1], Erin Pulster[1], Jamie Utz[2] and Shannon Meppelink[1] (1)U.S. Geological Survey (USGS), (2)Idaho Department of Fish and Game

Insects have many beneficial functions such as pollinating plants and serving as a food source for other animals. Research indicates that terrestrial insects are generally declining across the United States and globally. For example, the monarch butterfly (Danaus plexippus) is proposed to be listed as "threatened" under the Endangered Species Act. While the factors causing this decline are multifaceted, intensive pesticide use and subsequent environmental exposure to nontarget organisms are likely contributing factors. In the United States, over 450 insect species feed on or use various species of milkweed as host plants. Given the various dependencies of beneficial insects on milkweed, there is an important need to quantify exposures of pesticides in milkweed tissue. To help fill this research gap, the U.S. Geological Survey conducted a national assessment of milkweed plant contamination across the United States. The network consisted of a one-time sampling of 104

sites across 31 states from May through September 2024. At each sampling location, milkweed leaves were collected for the analysis of 177 target pesticide compounds. Sampled sites captured a range of primary land use within a 500-meter radius of milkweed collection (e.g., cultivated crops, pastures/hay, developed, forested). Preliminary results show pesticides were detected in 72% of all sites with 49 different pesticides (24 fungicides, 13 insecticides, 12 herbicides) detected in at least one milkweed leaf sample. The number of pesticides detected in a single sample ranged from 0 to 25. The most frequently detected pesticides were desethyl atrazine (28%, herbicide transformation product [TP]), azoxystrobin (21%, fungicide), bifenthrin (20%, insecticide), and propiconazole (20%, fungicide). The pesticides found in the highest concentration were 2,4-D (1,040 nanograms per gram [ng/g] wet weight, herbicide), propanil (331 ng/g, herbicide), desthio prothioconazole (183 ng/g, fungicide TP), azoxystrobin (146 ng/g, fungicide), and cyhalothrin (70.8 ng/g, insecticide). While sites proximal to cultivated crops had the most frequent detection of pesticides (94%), detections were also common in nonagricultural areas such as developed (62%), forested (50%), and grassland (40%), which documents that monarch butterflies and other insects can be exposed to pesticides via their host plant and food source in both agricultural and nonagricultural areas.

4.23.T-06 Advancements in the Detection of Pesticides in Canadian Waters Through the Canadian Water Monitoring Program for Pesticides

Myriame Lafrance[1], Janice Villeneuve[1], Cassie McLean[1], Alice Dove[1] and Jason Vanrobaeys[1] (1)Pesticides Regulatory Directorate, Healthy Environments and Consumer Safety Branch, Health Canada

Health Canada requires comprehensive water monitoring data to inform pesticide regulatory decisions for potential risks to human health and aquatic ecosystems. The Canadian Water Monitoring Program for Pesticides (CWMPP), established in 2022 and led by Health Canada, is a collaborative national initiative designed to generate high-quality environmental monitoring data to support pesticide regulation. The program integrates federal, provincial, local, and Indigenous partners to systematically collect and analyze water samples from diverse aquatic environments across Canada. Surface water samples (e.g., rivers, streams, lakes, and wetlands) are collected frequently during the growing season, while groundwater samples from wells are collected less frequently.

Site selection is risk-based and guided by a geospatial framework integrating national datasets, including Agriculture and Agri-Food Canada (AAFC) Indicator of Risk of Water Contamination by Pesticides (IROWC-PEST), the National Resources Canada (NRCan) National Hydro Network, and the AAFC Annual Crop Inventory. These inputs identify priority drainage areas with a higher likelihood of pesticide occurrence based on landscape characteristics, transport potential, and cropland distribution. Sampling is conducted in most provinces and territories in areas at risk of pesticide movement to water.

Samples are analyzed using multi-residue analytical methods capable of detecting over 200 pesticides, enabling comprehensive characterization of pesticide occurrence in Canadian waters. Monitoring results are publicly available and include pesticide concentrations, detection frequencies, and comparisons with human health and aquatic life reference values.

This presentation will provide an overview of the CWMPP, highlight initial findings, and describe how monitoring data are used by Health Canada to inform pesticide risk assessment and regulatory decision-making.

Pesticides in the Aquatic and Terrestrial Environment: Monitoring, Fate, Exposure and Ecological Effects

4.23.P-Tu147 Predicting the Peak: Multi-Year Monitoring of Pesticides in Irrigation Water Using Complimentary Sampling Techniques

Jonathan Challis[1], Ilakkiya Thirugnanasambandam[1], Tara Vucurevich[1], Mia Lahiji[2] and Tara Shelton[1] (1)Agriculture and Agri-Food Canada (AAFC), (2)University of Lethbridge

Alberta's irrigation networks are essential for supporting both crop and livestock production, making long-term monitoring of pesticide occurrence critical for protecting agricultural sustainability. From 2023 to 2025, irrigation water samples were collected monthly (June to September) from 70 sites across Southern Alberta using grab sampling. At six of these sites, diffusive gradients in thin films (DGT) passive samplers were co-deployed for three-week periods, continuously from May to October. High-frequency grab sampling was conducted at one of these sites twice-weekly. Atrazine, chlorantraniliprole, imidacloprid, metalaxyl, pyroxasulfone, and tebuconazole exhibited consistently high detection frequencies throughout the three-year period. Detection frequencies varied among the three years with 47, 32, and 46 compounds exceeding 10% detection threshold in 2023, 2024, and 2025 respectively, based on grab sample results. Mean and median concentrations of detected pesticides were 9.1 and 1.3 ng/L in 2023 (n=5,504), 25 and 0.28 ng/L in 2024 (n=4,820), and 3.9 and 0.19 ng/L in 2025 (n=5,020).

The co-deployment of DGT passive samplers at six of the grab sampling sites facilitated a comprehensive comparison of these two techniques. Overall, derived time-weighted average (TWA) concentrations were lower by DGT, with fewer detections at the low-end of the concentration distributions, compared to grab samples. The high-frequency grab sampling highlighted how and why concentrations between the two techniques can differ, in some cases significantly, when grab sampling captures a peak event. By pairing these two complimentary sampling tools, the known relationship between derived grab and TWA passive sampling concentrations was used to predict the type of event captured by the monthly grab sample. Parsing individual compound data revealed when a grab sample had likely captured a peak input event (grab >> DGT concentration), baseline levels (grab ≈ DGT concentration), or missed an input event entirely (grab << DGT concentration). This work provides a framework for using monthly grab sampling and continuous passive sampling in a complimentary manner to greatly enhance our understanding of pesticide dynamics and ultimately inform more accurate risk assessment.

4.23.P-Tu148 Modeling Source-to-Organism Pesticide Exposure and Bioaccumulation in Invertebrates in Small Streams

Melissa Bennett[1], Qianyang Wang[1], Johannes Raths[2], Juliane Hollender[2] and Maricor Arlos[3] (1)University of Waterloo, (2)Swiss Federal Institute of Aquatic Science and Technology (Eawag), (3)University of Alberta

The release of chemicals used for agricultural, commercial, or personal use into natural waterways has increased over the past decades. Although many legacy plant protection products (PPPs) have been banned, currently used formulations continue to enter receiving waters through ongoing agricultural and urban applications, creating continued exposure risks for aquatic organisms. Furthermore, recent studies in Swiss agricultural landscapes have shown that surface water concentrations of target PPPs alone cannot fully explain

the internal (whole body burden) concentrations observed in gammarids, an indicator aquatic invertebrate for water quality. Hence, these findings suggest that additional factors such as episodic transport, hydrologic connectivity, sediment-associated exposure, and dietary uptake may contribute to their bioaccumulation.
This study aims to determine which exposure pathway (or combination of pathways) primarily drives pollutant bioaccumulation in gammarids across different seasons (spring, autumn). To address this question, the strategy is to model whole source-to-organism exposure continuum by coupling hydrologic model, fate and transport, and toxicokinetic models to track pollutants from their sources to biological uptake endpoints. As a proof-of-concept, SWAT (Soil and Water Assessment Tool) was first applied to a predominantly small agricultural basin (2.19 km2, peak flow 0.7 m3s-1) to simulate (i) hydrologic processes and (ii) pesticide transport from field application through runoff pathways to the watershed outlet.
The low peak and base flows make modelling the small basin difficult, however, preliminary findings indicate successful application of SWAT to model hydrology (2019 – 2024) during calibration and validation stage (NSE = 0.6 (cal); 0.76 (val)), supporting the use of SWAT for further pesticide transport simulation. The model is currently being extended to characterize transport pathways of Fluopyram (a fungicide and nematicide) from fields to the nearby receiving stream and will be validated using observed surface water concentrations. Future work will incorporate observed data from sediments and leaf samples to simulate temporally varying whole-body burden in gammarids. Overall, this integrated framework will improve understanding of how multiple environmental pathways contribute to pesticide bioaccumulation under realistic field conditions.

Disclaimer/Disclosure: This project is in collaboration between the Swiss Federal Institute of Aquatic Science and Technology (Eawag) and the University of Waterloo.

4.23.P-Tu149 Emerging Aquatic Insects: A Relevant Contaminant Vector for Terrestrial Environments Globally

Jakob Wolfram[1], Stefano Larsen[2], Jeff Wesner[3], Darin Kopp[4], Jeffrey Muehlbauer[5], Johanna Kraus[6], Jose Manuel Álvarez-Martínez[7], Afroditi Grigoropoulou[8] and Ralf Schulz[1] (1)Rhineland-Palatinate Technical University Kaiserslautern-Landau (RPTU), (2)Research and Innovation Centre. Edmund Mach Foundation, San Michele all'Adige, (3)University of South Dakota, (4)USEPA/ORD/CPHEA/PESD/FEB, U.S. EPA, Corvallis, OR, (5)Alaska Cooperative Fish and Wildlife Research Unit, U.S. Geological Survey, Fairbanks, AK, (6)U.S. Geological Survey (USGS), (7)Biodiversity Research Institute (IMIB), University of Oviedo–CSIC–Principality of Asturias, Mieres, Asturias, (8)Department of Community and Ecosystem Ecology, Leibniz Institute of Freshwater Ecology and Inland Fisheries (IGB), Berlin

The production of anthropogenic chemicals has increased sixfold in the last decades and represents a major driver of global change. Streams and rivers receive contaminants from the surrounding landscape, but may also export them back to land via bioaccumulation and emergence of adult aquatic insects. While adult aquatic insects provide vital nutrient subsidies to terrestrial ecosystems, they, in return, also act as vectors for contaminant exposure to terrestrial food chains, potentially offsetting subsidy benefits. Despite their ecological importance, the global scale of these cross-ecosystem fluxes remains mostly unquantified. To address this, the AquaSync synthesis project encompassed three global meta- and data-analytical research areas, namely (1) global emerging insect biomass production, (2) biotic contaminant uptake and flux, and (3) global contaminant concentration in surface waters, which were ultimately combined to quantify global, cross-ecosystem contaminant fluxes. By pairing extensive datasets on in-stream insect production (>300 records), contaminant uptake (>800 records) and contaminant concentrations (>13 million records), we estimated that rivers export

~1.8 million tons of dry insect biomass annually. This includes ~17,000 tons of essential fatty acids, an amount exceeding that of other migratory animals like anadromous fish. We found an average export of ~1,680 mg of dry-mass m-2 yr-1 of adult aquatic insects, translating to ~750 mg of carbon m-2 yr-1, in line with previous estimates. Combined with global contaminant modelling, we estimated that approximately 368 tons of essential metal(loids) (Zn, Cu, Se) and 11 tons (Pb, Hg, Cd) of non-essential metals are exported from streams annually. In contrast, exports of twelve pesticides were substantially lower, totaling approximately 100 kg of active ingredients annually. Although pesticide exports where lower, their high potency and amplification through food chains likely makes them an ecologically important contaminant vector. Most emergence biomass is exported within 1 km of riparian zones, thus subsidizing nearly half of Earth's surface. In this talk, we aim to extend traditional views on contaminant management, which often focuses on individual environmental matrices, to cross-ecosystem fluxes that likely represent a vector of global relevance as well.

Disclaimer/Disclosure: Aquatic Synthesis Research Center SWG002 (326210499)
DFG GRK2360 SystemLink graduate college

4.23.P-Tu150 Responding to Invasion: A Baseline Assessment of Neonicotinoids and Aquatic Invertebrate Communities in Surface Waters Ahead of Application Changes in New York State

Evie S. Brahmstedt[1], Mark Petzold[2], Adrianna Hirtler[3], Jeremy Dietrich[1], Anna Haws[1], Ann Ghyzel[4], Don Riling[4], Kate Pochini[5] and Michelle L. Hladik[6] (1)New York State Water Resources Institute at Cornell University, (2)Seneca Lake Pure Waters Association, (3)Community Science Institute, (4)Save Our Sodus, (5)New York State Department of Environmental Conservation's Bureau of Habitat, (6)USGS California Water Science Center

Insecticides are used to protect crops such as corn, soybeans, and a variety of fruits in New York state (NYS). Certain insecticides, such as neonicotinoids (e.g. imidacloprid), can negatively impact non-target invertebrates, including those in adjacent aquatic environments. Currently, the Great Lakes/Finger Lakes (GL/FL) region of NYS is facing an emerging invasion of a new agricultural pest species: Lycorma delicatula or spotted lanternfly (SLF). The GL/FL region is at risk of consequences from widespread insecticide use to battle this invasive species due to the particularly high density of vineyards and orchards. It has been estimated that over $8 million USD could be lost to the regional economy within the first three years of SLF invasion. As such, growers have been actively preparing for SLF invasion and as part of their management strategy, have identified neonicotinoids as an effective treatment option. Thus, it is hypothesized that insecticide use, particularly neonicotinoids, will increase in use in the coming years. We predict elevated use will lead to increases in surface water concentrations of neonicotinoids and subsequent declines in aquatic invertebrate communities in streams with watersheds containing SLF-targeted crops. During the baseline years ahead of SLF invasion, we hypothesize neonicotinoids will be highest in corn and soybean dominated watersheds due to ongoing use of neonicotinoids in seed coatings. Starting in 2025-2026, baseline data collection was initiated to screen for streams with existing high neonicotinoid concentrations. These initial years will be used to generate a baseline dataset since no surface water neonicotinoid data has previously been published for this region and SLF has not invaded to an extent that we anticipate use of neonicotinoids for management in this region. Neonicotinoid detections were prevalent across sites, with certain neonicotinoids exceeding US EPA chronic thresholds for aquatic invertebrates at multiple sites. Exceedances often occurred after precipitation events and during high

flow. The baseline dataset generated here can be utilized in the coming years as a benchmark for comparison over time. While responding to invasive species is vital to the health of local economies and agriculture, we hope to capture any unintended consequences to non-target aquatic species and generate a conversation that advances sustainable management of natural resources across the GL/FL region.

4.23.P-Tu151 Pyrethroid Toxic Units as Predictors of Hyalella azteca Toxicity: Influence of Environmental Covariates and Implications for Surface Water Quality Monitoring

Berkley Anderson[1] and Thomas Young[1] (1)University of California, Davis

Pyrethroid insecticides are used in a wide range of agricultural, residential, and commercial applications and are frequently detected in aquatic systems where they can pose risks to sensitive species such as Hyalella azteca (H. azteca). In this study, pyrethroid bulk concentrations, organic carbon concentrations, and H. azteca survival reported in sediment (n = 854) and water (n = 790) samples across California from 2014-2024 were retrieved from the California Environmental Data Exchange Network (CEDEN). Toxic units in the sediment samples were estimated using organic carbon-normalized concentrations and a concentration addition approach. Toxic units in the water samples were estimated using freely-dissolved concentrations that were predicted using pyrethroid KOC and KDOC partition coefficients and a concentration addition approach. Toxic units were then modeled to the reported H. azteca 10-day and 4-day survival in sediment and water samples, respectively. The purpose of this study was to evaluate the performance of pyrethroid toxic units as a predictor of H. azteca toxicity. For sediment samples, 50% organism survival was predicted at a toxic unit of 1.30 ± 0.07 (± standard error) and the model was moderately strong overall (r2 = 0.47). Similarly for water samples, 50% organism survival was predicted at a toxic unit of 0.92 ± 0.05 (± standard error) and the model was weaker overall (r2 = 0.30). The unexplained variance in both models may be due to differences in organic matter quality or sorption capacities (KOC and KDOC), changes in environmental conditions (e.g. salinity), and/or presence of co-contaminants. Trends in the ability of pyrethroid toxic units to predict H. azteca toxicity across environmental covariates (i.e. land uses, seasons, environmental conditions, and presence of co-contaminants) and the implications for surface water quality monitoring will be examined.

4.23.P-Tu152 Glyphosate-Based Herbicide Applications and Tillage Did Not Alter the Abundance of Genes Involved in Glyphosate and AMPA Degradation in Agricultural Soils of the Montérégie Region (Québec, Canada)

Laurianne Ladouceur[1], Marc Lucotte[1], Jacynthe Masse[2], Matthieu Moingt[3], Caroline Halde[4], Philippe Seguin[5], Tanya Copley[6] and Charles Séguin[1] (1)UQAM, (2)Agriculture and Agri-Food Canada, (3)UQAM, LAE, (4)Université Laval, (5)McGill University, (6)CEROM

Introduction:
Glyphosate-based herbicides (GBH) are widely used in large-scale farming and their active ingredient, glyphosate, is now detected across various environmental compartments, particularly in agricultural soils. To better understand its environmental fate, we measured residual levels of glyphosate and its main degradation product, AMPA, and quantified the abundance of the goxA and soxA genes involved in microbial degradation under different agricultural practices.
Methods:
Forty-two fields representative of Quebec's main crops (corn, soybeans and cereals) were sampled in July 2023

and 2024. The selection included both conventional and organic systems, with tillage practices ranging from no-till to intensive. The abundances of the two genes were quantified using qPCR.
Results:
Results indicate that higher GBH application rates do not systematically lead to higher glyphosate and AMPA contents in soils. Furthermore, regardless of the GBH application ratesor tillage practices, no significant increase in the abundance of goxA and soxA genes was observed over the two-year study period.
Conclusion:
We found no clear link between agricultural practices, GBH application rates, and functional gene abundance for glyphosate and AMPA degradations. Microbial degradation alone may not explain glyphosate dissipation in soils, with other biological or abiotic processes likely contributing to its fate.

4.23.P-Tu153 Seasonal Variability and Threshold Exceedances of Pesticides in Salmon-Bearing Waterways of British Columbia, Canada

Jason Vanrobaeys[1], Janice Villeneuve[1], Carys Gallilee[2], Tanya Brown[2] and Mina Hassan Aghaei[2] (1)Pest Management Regulatory Agency, Health Canada, Government of Canada, (2)Simon Fraser University

Pacific salmonids are exposed to a complex mixture of contaminants, including legacy and current-use pesticides both during their early life stages and when they return to freshwater systems to spawn. There is evidence that both legacy and current-use pesticides have been shown to be toxic to salmon at environmentally relevant concentrations. However, there is no information on when pesticides are applied and discharged into British Columbia's salmon habitat and very little information exist on levels in water for the area, hampering solution-oriented opportunities for natural resource managers and stakeholders. Water samples has been collected weekly from August 2024 to August 2025 in five salmon bearing creeks and rivers (Musqueam and Hoy creeks, Serpentine, Nicomekl, and Sumas rivers) in the Lower Mainland, British Columbia where extensive forestry, agricultural, industrial and urban activities take place. Musqueam Creek, last creek in Vancouver with a wild salmon run, and Hoy Creek are at the receiving end of urban pesticide applications, while Serpentine River, Nicomekl River, and Sumas River are impacted more by agricultural pesticide discharges. Water samples were analyzed for approximately 200 pesticides, including active ingredients and transformation products. Preliminary results indicate that pesticide concentrations were highest during the spring and summer months, and some exceedances above aquatic life reference values were observed at most sites. Results will help identify critical areas and periods where risks to aquatic ecosystems are most significant, providing guidance for further research and potential improvements in salmon-bearing streams.

4.23.P-Tu155 Bioaccumulation and Tissue-Specific Distribution of Agricultural Pesticides in the Freshwater Mussel Elliptio complanata: A Biomonitoring Approach

Antoine Faure[1], Catherine Dubuc[1], Yannick Arnold Nombré[2], Lise Parent[3], Isabelle Lavoie[1] and Anne Crémazy[1] (1)Institut national de la recherche scientifique, (2)Université du Québec à Montréal, (3)Université TÉLUQ

Synthetic pesticides are frequently detected in surface waters worldwide and may pose risks to aquatic ecosystems. In this study, we evaluated the influence of a pesticide-contaminated agricultural tributary (Rousse Stream) on the downstream Grande Baie marsh in Oka National Park (Quebec, Canada) using water chemistry analyses and the freshwater mussel Elliptio complanata as a biomonitor.
Between June 4 and July 4, 2024, caged mussels were deployed in Rousse Stream, the Grande Baie marsh, and

a reference site (Oka bay). Water samples and mussel tissues (digestive glands, gills, foot and gonads) were analyzed for pesticide concentrations. Pesticide concentrations were highest in Rousse Stream, intermediate in the Grande Baie marsh, and lowest at the reference site, demonstrating downstream transport of agricultural contaminants into the marsh ecosystem. Chlorantraniliprole, hydroxychlorothalonil, imidacloprid, cyantraniliprole, thiamethoxam, and chlorpyrifos exceeded governmental water quality guidelines in Rousse Stream, with several exceedances also occurring in Grande Baie marsh.
Out of the 22 measured pesticides, nine were detected in mussel tissues, with marked differences among compounds and tissues. Chlorpyrifos exhibited the highest whole-soft-tissue bioaccumulation factor (BAF; 408 ± 70 L/kg), whereas most other pesticides had BAF < 10 L/kg. Pesticide tissue concentrations increased linearly with water concentrations across study sites, for the three pesticides that were consistently detected in the various sites and tissues (atrazine, chlorantraniliprole, and S-metolachlor). Distinct tissue-specific distribution patterns were observed, with gills, digestive glands, gonads, and foot tissues exhibiting different bioaccumulation potentials depending on the pesticide.
These results demonstrate that E complanata can serve as an effective biomonitor of agricultural pesticide contamination. More broadly, this study provides new information on the bioaccumulation and tissue-specific distribution of currently used pesticides in freshwater mussels and highlights the importance of considering tissue-specific accumulation when assessing pesticide exposure and ecological risk in aquatic ecosystems.

4.23.P-Tu156 Assessing the Acute, Developmental, and Reproductive Toxicity of the Novel Insecticide Isocycloseram in Grass Shrimp (Palaemon pugio)

Michella Salvitti[1], Katy Chung[2], Marie DeLorenzo[2] and Peter Key[2] (1)University of Maryland Eastern Shore, (2)National Oceanic and Atmospheric Administration (NOAA)

The increasing use of insecticides in agricultural, ornamental, and urban landscapes raises concerns regarding their transport into estuarine environments through stormwater runoff and tidal creek discharge. Isocycloseram is a recently registered insecticide that acts through inhibition of γ-aminobutyric acid (GABA) receptors and has demonstrated high efficacy against a variety of insect pests. With overlapping uses in the coastal zone, it is important to understand the potential impacts of isocycloseram on non-target estuarine organisms. The grass shrimp (Palaemon pugio) is an ecologically relevant estuarine crustacean widely used in toxicity testing due to its abundance, sensitivity to environmental stressors, and importance as prey for commercially and recreationally important fish species. The objective of this study is to evaluate the acute, developmental, and reproductive toxicity of isocycloseram across multiple life stages of P. pugio.
To assess acute toxicity, 96-hour LC50 experiments were conducted using both 24-hour-old larval grass shrimp and adult shrimp to determine life-stage-specific sensitivity thresholds. Mortality data was analyzed using dose-response modeling to establish toxicity benchmarks relevant to ecological risk assessment. Following determination of acute toxicity thresholds, a 21-day sublethal exposure study was conducted using larval shrimp exposed to relevant concentrations derived from the LC50 results. Developmental endpoints including survival, growth, and progression through larval stages were evaluated to identify potential sublethal impacts. Additionally, reproductive toxicity was assessed through a 10-day exposure study utilizing gravid female grass shrimp. Embryonic development, hatch success, and percent hatch were measured to determine whether isocycloseram exposure affects reproductive performance and early life-stage development. Together, these experiments will provide a comprehensive assessment of toxicity across multiple biologically relevant endpoints and life stages. Results will be compared to expected environmental concentrations and used to

inform application guidelines.

4.23.P-Tu157 Understanding Transformation Mechanisms of the Herbicide Metribuzin and Its Transformation Products in Soils and Groundwater With Compound-Specific Isotope Analysis (CSIA)

Louis Marchal[1], Violaine Ponsin[2] and Maria Prieto-Espinoza[3] (1)1 Department of Civil, Geological and Mining Engineering, Polytechnique Montréal, 2500 Chemin de Polytechnique, Montréal, QC H3T 1J4, Canada / 2 Université de Savoie Mont-Blanc, France, (2)3 Department of Earth and atmospheric sciences, Université du Québec à Montréal, University of Quebec in Montreal (UQAM), Canada / 4 Geotop, Canada, (3)1 Department of Civil, Geological and Mining Engineering, Polytechnique Montréal, 2500 Chemin de Polytechnique, Montréal, QC H3T 1J4, Canada / 4 Geotop, Canada

Metribuzin is a triazine herbicide widely used in North American agriculture to control broadleaf weeds and annual grasses. Recently, metribuzin has been detected in Quebec's surface water and drinking water, posing a significant threat to aquatic ecosystems and human health. Moreover, metribuzin is a highly soluble compound (1,2 g/L) prone to leaching into groundwater. While metribuzin is often included in environmental monitoring studies, metribuzin's transformation products (desamino-metribuzin (DA), diketo-metribuzin (DK), and desamino-diketo-metribuzin (DADK)), remain overlooked. Understanding the persistence and degradation pathways of metribuzin and its main transformation products remains a critical gap. Compound-Specific Isotope Analysis (CSIA) of carbon (13C/12C) and nitrogen (15N/14N) can be used to identify the transformation pathways of organic contaminants. This method relies on the kinetic isotope effect, where molecules containing lighter isotopes usually react faster than those with heavier ones, inducing a characteristic isotopic fractionation for each specific degradation pathway. Although CSIA has been developed and applied to study the transformation of various pesticides, including the triazine atrazine, it has not yet been developed for metribuzin.

The objectives of this study are to: 1) evaluate the degradation kinetics of the parent compound and its transformation products and, 2) determine the characteristic carbon and nitrogen isotopic fractionation factors (ε) associated with the degradation of metribuzin, DK, and DADK by different processes.

We performed laboratory-controlled degradation experiments on metribuzin, DK, and DADK under various conditions, including acid and alkaline hydrolysis, photolysis, and biodegradation in soil, water, and sediment matrices. First results indicate that acid hydrolysis is faster than alkaline and neutral hydrolysis, lasting only 27 h compared to 793 h and more than 5,000 h, respectively. During photolysis experiments, DADK had the shortest half-life (40 min), while DK was the longest to react (330 min) and metribuzin had an intermediate half-life (130 min). Ultimately, the obtained fractionation factors and dual-plots (15N/14N versus 13C/12C) will serve as a diagnostic tool to assess, directly from an environmental sample (e.g., soil, surface water, groundwater), whether metribuzin has undergone degradation and to identify the dominant degradation pathway occurring in the field.

4.23.P-Tu158 Advancing Mechanistic Interpretation of Non Extractable Residues: Application of a 4 Pool Kinetic Framework

Christiaan Wijntjes[1], Wenkui He[2], Hazel Walshaw[3], Stefan Schubert[2] and Ayanna Shoulds[1] (1)Corteva Agriscience LLC, (2)Corteva Agriscience Germany GmbH, (3)Corteva Agriscience UK Limited

Non-extractable residues (NER) remain one of the least harmonized components of environmental fate risk assessment, contributing to regulatory uncertainty and inconsistent interpretation across jurisdictions. In the European Union, increasing emphasis is placed on characterizing the nature and relevance of NER at high levels (>70% AR), whereas in the United States, NER are typically addressed more conservatively within bound residue frameworks, often without compound-specific differentiation. This divergence limits comparability of assessments and introduces inefficiencies, as NER evaluations frequently rely on assumption-based approaches rather than mechanistic evidence. Building on Huang et al. (2024), we present a 4 pool kinetic analysis framework that enables quantitative differentiation of residue fractions and identification of compounds or precursors driving NER formation. This approach links residue dynamics to underlying transformation mechanisms, providing a more scientifically grounded interpretation of NER behavior in soil systems. The framework has been implemented in a user-oriented NER software tool designed to support consistent, transparent analysis across radiolabeled studies. Application of the software demonstrates how mechanistic insights can reduce uncertainty in NER interpretation, improve comparability across studies, and strengthen the defensibility of environmental fate assessments. By enabling clearer differentiation between reversible sequestration and more stable incorporation into soil matrices, the approach supports more refined exposure and risk characterization. Presentation of this methodology provides an opportunity to engage regulators and stakeholders on a harmonized, science-based path forward for NER evaluation. Broader adoption of such approaches has the potential to improve regulatory efficiency and alignment, while advancing the scientific basis of NER assessment in both EU and US frameworks.

4.23.P-Tu159 A Study on the Stability of Dichlorvos, Chlorpyrifos, Chlorpyrifos Methyl & Imidacloprid in Honey & Pollen With Application of Non-Targeted Analysis

Vivian Benefoa Oppong[1], Lan Liu[1], Zhi Hao Chi[1] and Stéphane Bayen[1] (1)McGill University

Apiculture plays a major role worldwide, both economically and through its essential pollination services. In the last decades, the beekeeping industry has faced various events of mass mortality. Viruses and parasites (e.g. varroa) can cause bee colony mortality. Bee hives are also exposed to a range of pesticides, including insecticides and acaricides, which may play a role also in bee mortality events. Pesticide residues can contaminate bees and honeybee products through diverse routes, with consequences not only on bee health, but also on the quality of the products and their safety for consumers. In this context, pesticide residues are under regular monitoring in bees and honeybee products. Most samples are often tested as negative (no pesticides detected). However, a review of the current literature and practices has revealed that little is known about the stability of pesticide residues in honeybee matrices at temperatures occurring in bee hives (about 30°C) or during storage prior to analysis. While some pesticides remain stable, others will degrade at different rates depending on temperature, pH, light, enzymes, oxygen, matrix composition, etc. These reactions may also result in diverse degradation products, with potential toxicity.
In this study, the kinetic degradation and newly formed degradation products of four key residues (dichlorvos, chlorpyrifos, chlorpyrifos methyl & imidacloprid) were assessed in honey and pollen. Analytical approaches

based on “dilute-&-shoot” and ultra-sound assisted extraction methods were developed for this purpose for honey and pollen, respectively. Both targeted and Non-Targeted Analysis (NTA) using high-resolution mass spectrometry coupled with liquid and gas chromatography (LC-QToF & GC-QToF SPME) were deployed for instrumental analysis. Key findings showed diverse degradation products and predominantly a 2nd order degradation at the storage and beehive conditions in pollen and/or honey for all compounds. However, a 1st order observed in pollen at 35°C for dichlorvos. Different suites of degradation products were also identified using NTA in honey and in pollen. This suggests that key components of difference between honey and pollen (e.g. enzymes or proteins) influence the degradation patterns. This calls for the need to pay attention to pesticides in bee products and improve their risk assessment for bees and consumers via robust surveillance programs.

Disclaimer/Disclosure: This work was supported by the Gouvernement du Québec (Élaboration et évaluation d’un protocole d’échantillonnage et d’analyse pour la recherche de pesticides en cas de mortalité massive aiguë d’abeilles) and the Canada Foundation for Innovation (Project #35318) of S. Bayen.

4.23.P-Tu160 Indoor Residual Contamination by Neonicotinoids in Africa: Evidence From Household Dust and Human Biomonitoring in Ghana

Osei AKOTO[1], Nathaniel BOADI[2], Shouta M.M. NAKAYAMA[3], Yoshinori IKENAKA[4], Mayumi ISHIZUKA[3] and Collins Nimako[5] (1)Chemistry Department, Kwame Nkrumah University of Science and Technology, Kumasi., (2)Chemistry Department, Kwame Nkrumah University of Science and Technology, Kumasi, (3)Laboratory of Toxicology, Department of Environmental Veterinary Sciences, Faculty of Veterinary Medicine, Hokkaido University, Kita 18 Nishi 9, Kita-ku, Sapporo 060-0818, (4)One Health Research Center, Hokkaido University, Sapporo 060-0818, (5)Laboratory of Toxicology, Department of Environmental Veterinary Sciences, Faculty of Veterinary Medicine, Hokkaido University, Kita 18 Nishi 9, Kita-ku, Sapporo 060-0818 Japan

Neonicotinoid insecticides are the most widely used insecticides globally; however, information on their indoor residual contamination remains limited, particularly in Africa, where these compounds are currently used in approximately 53 countries. This study comprehensively assessed indoor contamination by neonicotinoids using household dust as a proxy and evaluated associated human exposure and health risks across 12 agrarian communities in Ghana, West Africa. A total of 430 household dust samples and 1,066 paired urine samples were collected and analyzed using liquid chromatography–tandem mass spectrometry. Ten neonicotinoids were detected in indoor dust, and detection frequencies followed the order: imidacloprid and its metabolites (99.1%) > acetamiprid compounds (93.7%) > thiamethoxam (89.5%) > clothianidin (82.1%) > sulfoxaflor (74.2%). Median dust concentrations were highest for imidacloprid (0.145 μg/g), followed by thiamethoxam (0.030 μg/g), acetamiprid (0.014 μg/g), sulfoxaflor (0.003 μg/g), and clothianidin (0.002 μg/g). Urinary biomarkers of neonicotinoids were found, with detection frequencies decreasing in the order: acetamiprid compounds (99.8%) > imidacloprid compounds (92.9%) > thiamethoxam (88.6%) > clothianidin compounds (78.6%) > sulfoxaflor (60.9%). Median urinary concentrations were highest for imidacloprid biomarkers (0.66 μg/g Cre), followed closely by acetamiprid biomarkers (0.65 μg/g Cre), whereas lower concentrations were observed for clothianidin (0.14 μg/g Cre), thiamethoxam (0.13 μg/g Cre), and sulfoxaflor (0.04 μg/g Cre). Linear regression analyses between dust concentrations and urinary biomarker levels showed weak associations ($R^2 < 0.1$), suggesting that human exposure is likely driven by multiple pathways beyond indoor dust ingestion or inhalation. Risk assessment based on urinary biomarker-derived estimated daily intakes indicated that both

median and maximum exposures to all detected neonicotinoids were substantially higher among adolescents aged 12–19 years than among adults (>20 years) and children (<12 years). Although hazard quotients (HQs) for all neonicotinoids across age groups were generally below 1, elevated risks were identified in a small subset of participants. Specifically, two individuals exhibited imidacloprid HQs greater than 2, while seven individuals had cumulative neonicotinoid HQs exceeding 1, suggesting potential health concerns among highly exposed individuals.

Disclaimer/Disclosure: This research was supported by JST AJ-CORE (PJ36210002), JSPS CORE to CORE program, JST/JICA SATREPS (Science and Technology Research Partnership for Sustainable Development; No. JPMJSA1501), and aXis (Accelerating Social Implementation for SDGs Achievement; No. JPMJAS2001).

4.23.P-Tu161 Can We Use Thiamethoxam and Flupyradifurone Concentrations in Leaves To Predict Concentrations in Nectar?

Patrick Wilson[1], Vanesa Rostan[1], Mia Cabrera[1] and Sandra Wilson[1] (1)University of Florida

Declines in pollinator populations have gained much attention over the last decade. Exposures to pesticides are one potential contributor to these declines. Our previous research has shown that applications by drench result in significantly higher concentrations of thiamethoxam and flupyradifurone in nectar relative to spray applications. Likewise, nectar contamination was significantly correlated with application rates. Given that the ornamental plant production industry produces crops that are attractive to pollinators and that pesticide use is often integral to ensuring plants are pest-free, attention is needed to assess and possibly reduce contamination of flower nectar before plants go to market. Major challenges to conducting research on contamination of nectar with pesticides include tedious collection methods and the limited volume of nectar produced by many ornamental plants. The objectives of this project were to assess the feasibility of using concentrations of thiamethoxam and flupyradifurone in leaves to predict concentrations in nectar. Commercial formulations of thiamethoxam and flupyradifurone were applied by drench to non-flowering Salvia coccinea plants in 0.94 l containers in a greenhouse at low, medium, and high rates based on the labels. At flowering, samples of nectar and leaves were taken for analysis by LC-MS/MS. Results indicate that concentrations of both insecticides increased with increasing application rates, ranging from 58 to 143 ng/mL (thiamethoxam) and 30-62 ng/mL (flupyradifurone). Likewise, concentrations in leaves were orders of magnitude higher and proportional to application rates. Concentrations in leaves and nectar were correlated with R2 values greater than 0.84 when including all data points and greater than 0.95 using only treatment means. Depending on allowable uncertainty, leaves may be useful for predicting concentrations of some systemic pesticides in nectar.

Pesticides in the Aquatic and Terrestrial Environment: Monitoring, Fate, Exposure and Ecological Effects

4.23.V-01 Evaluation of Diazinon Toxicity on Juveniles of African Catfish, Clarias gariepinus (Teugels)

Patricia Uchenna Okeke[1] and Emmanuel Ogbomida[2] (1)University of Benin, Benin-City, Edo State, Nigeria., (2)National Center For Energy and Environment.

The acute and sub-lethal toxicity of the organophosphate pesticide, Diazinon (DZN) (O, O-diethyl-6-methyl-4-pyrimidinyl] phosphorothioate) to juveniles of African catfish, Clarias gariepinus, was evaluated under laboratory conditions using 60 L glass aquaria supplied with aerated dechlorinated water. The study was motivated by the widespread agricultural and domestic use of diazinon in Nigeria and the growing concern over its harmful effects on non-target aquatic organisms. Juvenile fish with mean weight and standard length of 24.59 ± 1.5 g and 13.79 ± 0.2 cm were exposed to nominal diazinon concentrations of 2.43, 4.06, 7.29, 9.22, and 12.15 mg L^{-1} for 96 h. The 96 h LC50 value was estimated at 6.03 mg L^{-1}, indicating high toxicity of diazinon to the species. Toxic effects were assessed at cellular, organ, and whole-body levels, demonstrating the novelty of a multi-level biomarker approach in evaluating pesticide toxicity. Hematological alterations included reduced hematocrit and total erythrocyte count, alongside significant changes in leukocyte levels compared with the control. Histopathological examination revealed oedema, atrophy, and hyperplasia of gill lamellae, resulting in severe disruption of gill structure, while liver tissues showed hepatocyte degeneration, necrosis, and reduced vacuolation. Behavioral abnormalities such as erratic swimming, air gulping, loss of equilibrium, body twisting, quiescence, and mortality were also observed. Furthermore, diazinon exposure impaired nutrient utilization and significantly reduced carcass nutritive value ($P < 0.05$). The study recommends stricter regulation and monitoring of diazinon usage to minimize ecological and public health risks in aquatic environments.

Disclaimer/Disclosure: The authors declare that no specific grant, funding, or financial assistance was received from public, private, or non-profit organizations for the conduct of this study

Plastics and Plastic-Associated Contaminants as Environmental Mixtures: Monitoring, Fate, Effects and Interactions

4.24.T-01 Uncovering the Relative Importance of Chemical Emissions Arising From the Application As Plastic Additives

Chengkang Chen[1], Ziqi Zhang[1] and Frank Wania[1] (1)University of Toronto

Synthetic chemicals can be used simultaneously in various applications including as plastic additives. With the rapid rise in plastic production and the associated pollution, it is vital to investigate the relative contribution of the application as plastic additives to chemical emissions and subsequently to human and wildlife exposure. We select four groups of chemicals, i.e., polychlorinated n-alkanes (PCAs), polychlorinated biphenyls, polybrominated diphenyl ethers, and organophosphate esters, and apply the dynamic substance flow analysis model (CiP-CAFE) to revisit their global historical emissions. We compare emissions of these chemicals arising from their application as additives in plastic products with those from other applications. Using the derived

emission estimates as input, we further apply the chemical fate model BETR-Global to assess to what extent emissions arising from plastic additive applications contribute to the environmental exposure to these chemicals globally. Our findings uncover a large contribution of application as plastic additives to total emissions. Taking PCAs as example, 20% of PCA global historical emissions during 1930-2020 are attributed to the use as plastic additives, with this contribution varying between regions and with time. PCA emissions from plastic additives application are more likely to lead to PCA emissions into the atmosphere, while emissions from other applications are more likely to be to fresh water and soils. Accordingly, plastic additive use of PCA makes a large contribution to global atmospheric contamination. For example, over 60% of short-chain PCAs (SCCPs) in the global atmosphere are attributed to the emissions of SCCPs as plastics additives. This percentage is even higher in China where ~90% of SCCP use is as additive. This work advances our understanding of the vital importance of plastic additives to the emissions of, and therefore ultimately to the human exposure to, many contaminants.

Disclaimer/Disclosure: The study is financially supported by the NSERC-ECCC Plastics Science and Innovation for a Cleaner and
More Sustainable Future Grants (ALLRP 607337-25).

4.24.T-02 What's Beneath the Surface: Assessing Parameters That Influence the Leaching of Persistent, Mobile, and Toxic Plastic Additives From Various Plastic Items

Eric Fries[1], Huy Nguyen[1], Yanan Li[1], Bonnie Hamilton[2] and Roxana Suehring[1] (1)Toronto Metropolitan University, (2)University of Ottawa

While microplastics often lead the narrative on the threat of plastic pollution, an area of growing concern is the associated chemical threat. Plastic additives, such as flame retardants, plasticizers, and UV stabilizers, can leach out of plastics, contaminating aquatic environments. While several classes of additives have been researched, a group that remains understudied are those that are persistent, mobile, and toxic (PMT). PMT plastic additives can pose a substantial risk to water quality, as their high environmental stability and low adsorption potential make it possible for these contaminants to pass through water treatment processes and remain in the environment long after release. Despite the threat that PMT substances pose to aquatic resources, they remain unregulated in Canada, and are largely unregulated globally, likely being used in countless plastic items. There remain large knowledge gaps concerning the scale of PMT plastic additive use, their leaching behaviour, and the extent to which these substances may be actively threatening water resources. Beginning to fill in these knowledge gaps is a crucial step towards source identification, increased monitoring, and eventual regulatory action on these substances.

Herein, we present the investigation of PMT plastic additive leaching across multiple studies, including weathered and store-bought plastics, virgin and recycled polyethylene drinks bottles, textiles, and clothing fibres. More than 100 plastic items were investigated using a previously published PMT leaching protocol and high-performance liquid chromatography with quantitative time-of-flight mass spectrometry analysis methods. Suspect screening results of the leachates showed significant differences in the numbers and levels of PMT substances measured based on environmental exposure, as well as differences based on product/polymer type, locality, and PMT use categories. The most frequently and abundantly measured substances, such as 2-amino-5-methyl-benzenesulfonic acid and 2,6-xylidine, are highlighted as high-priority substances for environmental

monitoring and possible regulation. Combined, these works begin to cover the landscape of PMT plastic additive leaching, building an initial understanding of the factors influencing leaching, as well as specific plastics (e.g., toys, hardware supplies) and individual PMT substances that should be prioritized for future monitoring and regulation efforts.

4.24.T-03 Expanding Environmentally Relevant Analytical Targets for Plastics and Plastic Associated Chemicals Using Controlled Laboratory Weathering Scenarios

Liam Green[1], Chelsea Rochman[2] and Meredith Seeley[3] (1)William & Mary's Batten School of Coastal & Marine Sciences and the Virginia Institute of Marine Science, (2)University of Toronto, (3)William & Mary's Batten School of Coastal & Marine Sciences | The Virginia Institute of Marine Science

Microplastics have been identified as vectors of organic contaminants in aquatic environments. One method of such transport is the release of plastic associated chemicals (PACs) into surrounding matrices, through passive diffusion and with the influence of environmental weathering processes. Weathering processes may influence PAC release by altering the polymer matrix, as well as chemically transforming the PACs into a variety of transformation products. While the release of these chemicals from different polymer matrices is increasingly well parameterized, the transformation of many PACs remains poorly understood. This is a critical research need, as there is evidence that transformation products can be more toxic than their parent compounds, and many PACs are specifically designed to react following environmental pressures (e.g., antioxidants acting as a chromophore and oxidizing to protect polymer integrity during photooxidation). This study investigates the transformation and leaching of an antioxidant and UV-stabilizer mixture from plastics under controlled, laboratory scenarios. Two plastic polymers (polyethylene and polystyrene) with known loadings of plastic additives (Irgafos-168, Benzotriazole-Acetostab 236 and Irgafos 126) were used for analyses. Sequential thermal desorption and pyrolysis – gas chromatography/mass spectrometry (TD- & Py-GC/MS), a combined targeted and non-targeted approach, was employed to identify and quantify changes in the relative abundance of target PACs under increasing durations of artificial UV exposure and hydrolysis. Analyses were completed with three artificial weathering processes: leaching in water under a UV weathering chamber, leaching in water without any UV exposure, and direct analysis following weathering in air via an in-line UV-irradiator affixed to the Py-GC/MS. Experiments were conducted with both the plastics containing PACs and the corresponding PAC standards. We confirmed that photooxidation and hydrolysis of PACs produced oxidized transformation products within the plastic, resulting in an increasing abundance of transformation products relative to their parent compounds over time. The results of this study demonstrate the importance of including transformation products in targeted analyses of PACs in environmental samples. In addition, the use of novel, replicable approaches makes this a widely accessible and applicable workflow for future studies.

4.24.T-04 Associations Between Microplastic Ingestion and PFAS Accumulation in Freshwater Fish

Mallory Christenson[1], Ella Kinart[2], Brittany Welsh[2], Julian Aherne[2] and Mary-Claire Buell[2] (1)Centre of Toxicology, University of Saskatchewan, (2)School of the Environment, Trent University

Aquatic contaminants such as microplastics and per- and polyfluoroalkyl substances (PFAS) have garnered substantial scientific and public attention due to their persistence and potential for bioaccumulation. However, their combined presence in fish tissues remains largely unknown, potentially posing a combined toxicological

effect and a transport pathway into fish species such as Sander vitreus and Coregonus clupeaformis. This study examined the co-occurrence of microplastics and PFAS in fish muscle and stomach tissue from three Ontario lakes and evaluated whether microplastic concentrations were associated with PFAS accumulation. Preliminary data through a Spearman correlation heatmap revealed that there was some correlation between microplastic concentrations and certain PFAS found in Lake Erie, suggesting that an association between microplastic ingestion and PFAS accumulation in the muscle tissue could be possible. Differences in contamination patterns between the three lakes studied, Lake Erie, Anjigami Lake, and Hawk Lake, suggest that local environmental factors influence microplastic and PFAS dynamics. Potential contributing factors include the presence of wastewater treatment plants, effluent discharges, and the persistence of historically used PFAS in the environment. The comparison of two remote lakes and one urban lake showed differences in individual contaminant concentrations, with Lake Erie possessing higher counts of microplastics and Anjigami and Hawk Lake having higher counts of PFAS. These findings improve the understanding of contaminant transport pathways in freshwater ecosystems and may inform future monitoring and risk assessment efforts.

4.24.T-05 Processes of Environmental Plastic Weathering and Biodegradation in In Vitro Experiments Mimicking Natural Ecosystems

Jessica Choi[1], Lizy Michaelson[2], Rachel Cable[2], Shuqing Zhang[2], Ting Lin[2], Piyush Thakre[3], Yujing Tan[3], Zhan Chen[2] and Melissa Duhaime[2] (1)Dow, Inc., (2)University of Michigan, (3)Dow Inc.

Plastic waste mismanagement and subsequent anthropogenic accumulation have garnered global attention related to plastics end of life. their sustainability, and ultimate fate in the environment. In fact, fully understanding the factors affecting environmental fate and transport of plastics has become important to inform mitigation strategies, modeling efforts, regulatory policies, and more. In many models, the effects that microbe-plastic interactions have on plastic environmental fate and transport are not considered, but we know these interactions can impact where plastics ultimately end up. Our research aims to identify and measure the effect of specific microbe-plastic interactions through in vitro experiments that mimic freshwater ecosystems. We have previously conducted in situ experiments in two freshwater lakes and determined that in situ microbial colonization is dependent on depth within the lake, duration in the lake, and polymer formulation. We then performed two in vitro experiments: first, using single-strain cultures of already-identified PE degraders (that were also found in our in situ work); and second, using microbial consortia cultures derived from the in situ plastic samples. Our single-strain culture experiments showed fungi remineralized more PE-derived carbon to CO2 as compared to bacteria. In fact, rates of CO2 evolution by fungi were at least 20x higher than by bacteria, indicating immense potential for fungal plastic biodegradation that largely remains unexplored. We also conducted in vitro experiments with 13C-labeled PE and microbial consortia cultures. Consortia are mixtures of microbial populations that can work synergistically to degrade recalcitrant substances. We hypothesize that consortia will be more effective than single-strain cultures in degrading PE. The use of 13C-labeled PE in our experiment allowed us to discern different degradation products and calculate cell-specific degradation rates. These metrics are important to: (1) establish new metabolic models of PE-degraders; (2) develop bioengineered solutions for enhanced PE degradation; and (3) predict outcomes for different PE compositions and environmental conditions that can inform design around PE circularity.

4.24.T-06 Chemical Leachables From Single-Use Food Contact Materials: A Non-

Targeted Study Under Consumer-Use Conditions

Donald Bimpong[1], Zhi Hao Chi[1], Nathalie Tufenkji[1] and Stéphane Bayen[1] (1)McGill University

Single-use plastics are widely used as food-contact materials, yet the environmental fate and identity of chemicals migrating from these materials into food after consumer use are poorly characterized. While traditionally evaluated strictly through a human dietary exposure lens, consumer-driven degradation accelerates the fragmentation of these materials, transforming them into significant sources of environmental chemical pollution. This study applied non-targeted analysis using liquid chromatography-quadrupole time-of-flight mass spectrometry (Agilent Technologies) to characterize organic leachables from take-out containers under simulated consumer-use and environmental-release conditions. Single-use plastic containers were subjected to three treatments reflecting real-world physical and thermal stress: (i) scratching to mimic cutlery abrasion, generating surface damage, (ii)microwaving, and (iii)generation of secondary microplastics. Leachates were prepared using 10 mL of 3% acetic acid for 10 days to simulate acidic food contact. Feature extraction using Profinder (Agilent Technologies) detected 4,461 molecular features across treatment samples. Statistical analysis using Mass Profiler Professional (Agilent Technologies) of overall chemical profiles revealed chemical features of interest between scratched and non-scratched containers. Furthermore, MS/MS data for selected suspects were acquired using a targeted MS/MS method, followed by structure elucidation with SIRIUS/CSI: Finger ID. Several additives and potential non-intentionally added substances (NIAS) of toxicological concern were found. This work demonstrates the application of NTA in characterizing complex chemical mixtures and also highlights how initial consumer-use conditions fundamentally alter the long-term chemical pollution footprint of single-use plastics entering the environment.

Plastics and Plastic-Associated Contaminants as Environmental Mixtures: Monitoring, Fate, Effects and Interactions

4.24.P-We218 Unpacking PET: Comparative Analysis of Leachable and Extractable Contaminants From Virgin and Recycled Polyethylene Terephthalate Bottles and Textiles

Yanan Li[1], Eric Fries[1], Gillian Z. Miller[2], Jeff Gearhart[2], Dayton McGrail[3], Christopher Kassotis[3] and Roxana Suehring[1] (1)Toronto Metropolitan University, (2)Ecology Center, (3)Wayne State University

Plastics, particularly polyethylene terephthalate (PET), are widely used as food contact materials, textiles, and toys. However, their widespread use and potential for human exposure raise environmental and health concerns, particularly regarding the leaching of chemical additives. This study assessed hazardous plastic additives and non-intentionally added substances (NIAS) leached from paired virgin and recycled PET bottles (soda and water) purchased from Michigan and California and from textiles (toys, pillows, and clothing) acquired online or in stores in Michigan and Oregon. Results showed differences in contaminant profiles and concentrations between PET types and products. A total of 12 persistent, mobile, and toxic (PMT) additives, six organophosphate esters (OPEs), and 15 NIAS were detected. Notably, recycled PET (rPET) bottles consistently contained benzene, while virgin PET had higher ethylene glycol and 2-methyl-1,3-dioxolane levels. Additionally, OPEs were detected more frequently in rPET, indicating recycling as a contamination pathway. Geographically distinct contaminant profiles were evident, with Michigan bottles exhibiting elevated benzaldehyde, while California bottles showed higher diethylene glycol levels, suggesting differing manufacturing practices. Textiles exhibited distinct contamination profiles, highlighting a distinct exposure

pathway for watersheds through laundry processes. Bioactivity assays with PET product extracts revealed moderate to high hormone receptor antagonism but no clear association with PET type, indicating potential hazardous effects from both virgin and recycled PET products. This study highlights the necessity of continued monitoring of contaminants in PET, including non-intentionally added substances and PMT plastic additives that are not currently regulated.

4.24.P-We219 Migration of Microplastics, Nanoplastics, and Plastic-Associated Chemicals From Breastmilk Storage Bags

Dana Kadadou[1], Karla Parga Martinez[1] and Nathalie Tufenkji[1] (1)McGill University

The use of plastic in food contact articles, particularly in baby products such as breastmilk storage bags and reusable food pouches, has raised concerns about potential ingestion of microplastics and nanoplastics by infants. Despite the growing research interest, robust analytical detection and quantification of plastic-derived constituents from such articles remain a significant challenge. This is largely due to several limitations, including low particle concentrations, lack of standardized protocols, inconsistencies in sampling methods, and poor quality assurance and control measures. We hypothesize that breastmilk storage bags release plastic-derived particles and associated chemicals under simulated use conditions, with release patterns influenced by exposure conditions. In this study, we investigated this release from commercial breastmilk storage bags under controlled laboratory conditions simulating realistic usage scenarios. Articles were subjected to migration experiments using selected food simulants, followed by leached particle and chemical characterization. Microplastics and nanoplastics were identified and quantified using complementary techniques, such as scanning electron microscopy, optical photothermal infrared spectroscopy, nanoparticle tracking analysis, and pyrolysis gas chromatography mass spectrometry. In parallel, released organic and inorganic chemicals were analyzed using liquid chromatography–mass spectrometry and inductively coupled plasma–mass spectrometry. Rigorous quality assurance and control procedures, including procedural and contamination controls, were implemented throughout the study to minimize contamination and ensure data reliability. Results show the release of particles consistent with the composition of breastmilk storage bags, with variability in particle morphology and size distribution depending on the simulant, exposure conditions, and brand. Nanoparticle tracking analysis indicated the presence of abundant nano-sized particles not fully captured by microscopy-based approaches, highlighting the importance of complementary analytical methods for comprehensive characterization. Overall, this work provides insights into the release of microplastics, nanoplastics, and plastic-associated chemicals from baby-specific food contact articles and highlights the need for improved methodologies and standardized workflows to better assess early-life exposure risks.

4.24.P-We220 Characterization of PFAS Leaching From Polymers: Implications for Laboratory and Environmental Contamination

Geneviève Tremblay[1], Olivia Marko[1] and Shira Joudan[1] (1)University of Alberta

Per- and poly-fluoroalkyl substances (PFAS) are commonly used as monomers, processing aids, and additives during the manufacturing of polymers, and fluoropolymers are classified as PFAS themselves. [SJ2.1]Although PFAS have desirable properties, they also pose risks to human health and the environment. They are persistent, can undergo long-range transport, and some have known toxic endpoints. Previous works have found that both

fluoropolymers and non-fluorinated polymers [SJ3.1]present in laboratory equipment can be sources of PFAS. This work aims to expand the current understanding of PFAS leaching from polymers, both as a source of environmental contamination and a source of laboratory contamination. Leaching will be investigated in deionized water and methanol to mimic laboratory contamination. River water from the North Saskatchewan River and an ocean water surrogate will be used to evaluate environmental leaching. To determine the effects of polymer ageing on PFAS leaching, 2 experiments will be conducted. Polymers will undergo accelerated ageing under UV-A lights both in the presence and absence of hydrogen peroxide, commonly used to form OH radicals which are relevant to advanced oxidation processes. Overall, 6 types of fluoropolymers and 2 types of non-fluorinated polymers will be assessed. Ultra-high performance liquid chromatography with tandem mass spectrometry will be used to quantify 44 PFAS with variable chain lengths (C1-C16) and functional groups (e.g., carboxylic acids, sulfonic acids). It is expected that the variety and total leachable PFAS will vary by polymer type and conditions. The results could be used to inform polymer choices in the lab and could provide insight into the environmental leaching of PFAS from polymers.

4.24.P-We221 Mechanical Tearing Induces Size Dependent Surface Reactivity in PET and HDPE Microplastics and Nanoplastics

Unnikrishnan Kannan[1], Sangeeth K[2], Jijo Lukose[2], Jian Wang[3], Vinod TP[4] and Saji George[1] (1)McGill University, (2)Manipal Institute of Applied Physics, Manipal Academy of Higher Education, Manipal - 576104, Karnataka, India, (3)Canadian Light Source, Saskatoon, SK S7N 2V3, Canada, (4)Department of Chemistry, Christ University, Hosur Road, Bengaluru 560029, India

Mechanical tearing is a major pathway for the formation of secondary microplastics and nanoplastics from larger plastic materials. Although increased surface reactivity has been proposed as a key mechanism that may enhance nanoplastic hazard, direct experimental evidence remains limited. Here, we show that polyethylene terephthalate (PET) and high density polyethylene (HDPE) sheets undergo linked structural, chemical, and functional transformations during mechanical tearing. Raman and FTIR spectroscopy confirmed that the core polymer identity was retained across the bulk, microplastic, and nanoplastic fractions. However, morphological and chemical characterization revealed clear size dependent changes in morphology, dispersion behavior, surface charge, oxygen chemistry, nanoscale chemical heterogeneity, and crystallinity. The nanoplastic fractions showed the strongest surface roughening, structural disorder, and chemical heterogeneity. The surfaces of PET particles became oxygen enriched, with increased C-O and O-C=O groups during size reduction. In contrast, HDPE remained mainly hydrocarbon rich, but showed clear structural disorder and interfacial reconstruction. EPR, HPF, and acellular DCFH assays further showed stronger radical associated and oxidative activity in nanoplastics than in microplastics. The increased reactivity was biologically relevant. Nanoplastics caused greater erythrocyte membrane perturbation and stronger intracellular oxidative stress in Caco-2 cells. Bovine serum albumin corona formation reduced cellular oxidation, confirming that accessible particle surfaces drive biological reactivity. Overall, these findings establish mechanical tearing as a mechanochemical route that converts pristine polymers into size dependent and polymer specific reactive interfaces. The results show that nanoplastic hazard is not controlled only by polymer identity or size. Instead, it emerges from fracture induced surface reconstruction, chemical heterogeneity, structural disorder, and biological surface accessibility.

Disclaimer/Disclosure: Saji George acknowledges support by CRC/George/X-coded/248475 and NSERC discovery grant for this work.

4.24.P-We222 Spectral Insights Into the Surface Changes of Ten Plastic Types Under Long-Term Field Exposure in Biscayne Bay, Florida

Maria Nolasco Banegas[1] and Piero Gardinali[2] (1)Florida International University, (2)Florida International University (FIU) Institute of Environment

Plastic surfaces change after exposure to weather conditions. Surface weathering can modify plastics physically and chemically, affecting mechanical properties and infrared spectral fingerprints. These changes can hinder reliable microplastics identification using surface-based techniques, such as Fourier Transform Infrared (FTIR). Additionally, weather experiments, mostly based on artificial or simulated environmental conditions, limit our understanding of the physicochemical changes in plastic under real-world exposure. Long-term exposure is therefore needed to assess changes, improve detection and identification of microplastics, and to better understand the fate and potential effects of plastics in marine environments. This work aims to document spectral changes during the degradation of ten plastic types by monitoring their surface and chemical changes under long-term exposure in Biscayne Bay, FL. Ten plastic types found in Biscayne Bay, being High- and Low-Density Polyethylene (HDPE, LDPE), Polypropylene (PP), Polystyrene (PS), Polyethylene terephthalate (PET), 100% recycled Coca-Cola bottle (rPET), Polyamide Nylon (PA), Polycarbonate (PC), Polyvinyl Chloride (PVC), and Acrylonitrile Butadiene Styrene (ABS) were deployed in stainless steel mesh bags in Biscayne Bay, retrieved at different timepoints and measured using ATR-FTIR. Preliminary results show visible biofilm colonization and surface dulling developed on all plastics after 1 month, with more complex biofilm structures appearing over time. Spectral changes were more evident after 3 months in HDPE, LDPE, and PP, mainly by broadening or enhancement of the 1000-1250 cm^{-1} region, broad 3000-3600 cm^{-1} features, and possible changes in carbonyl-related bands between 1550-1750 cm^{-1}. However, by 6 months, several spectra appeared closer to the controls, especially for HDPE and PP, while LDPE retained a weaker 1000-1280 cm^{-1} feature. PVC showed more evident 6-month changes, including bands in the 1000-1150 cm^{-1} and 3000-3600 cm^{-1} regions, whereas PA, PC, PET, rPET, and PS remained comparatively stable. These non-linear spectral trends suggest strong biofilm, mineral fouling, and surface heterogeneity influence at early marine exposure, with possible contributions from early oxidation. These findings highlight that biofilm accumulation can alter plastic spectral fingerprints, potentially reducing identification reliability while increasing reactive surface sites for contaminant sorption and transport.

4.24.P-We223 Influence of Porous Asphalt Pavement on the Wash-Off Behavior of Tire and Road Wear Particles (TRWP) and 6PPD-Quinone Under Seasonal Urban Road Conditionsin Japan

Junko Hara[1] and Wataru Naito[1] (1)National Institute of Advanced Industrial Science and Technology (AIST)

Tire and road wear particles (TRWP) are a major source of urban non-exhaust traffic emissions. Recent concern has focused on tire-derived additives such as 6PPD-quinone (6PPD-Q), an emerging contaminant with acute aquatic toxicity. Although laboratory studies have examined TRWP generation and chemical emissions, limited field-scale data exist on how pavement structure influences the wash-off of TRWP-associated contaminants under real urban conditions.

This study investigated the effects of pavement type and seasonal conditions on the runoff characteristics of TRWP-associated particles and dissolved chemical constituents from urban roads in Japan. Field measurements were conducted on porous asphalt pavements and dense-graded asphalt pavements under comparable traffic

conditions. Controlled water-spraying experiments were performed to simulate rainfall-induced wash-off processes, and runoff samples were collected for both particulate and chemical analyses.
Particular focus was placed on the detection and quantification of 6PPD-Q as a representative tire-derived oxidation product. Sampling was conducted in early spring (March) and late summer (September) to evaluate potential seasonal variations associated with pavement temperature, atmospheric conditions, and traffic-related accumulation processes.
The results revealed clear differences in wash-off characteristics between pavement types. Porous asphalt pavements exhibited distinct particle mobilization and retention behaviors compared with dense-graded pavements, indicating that pavement surface structure strongly influences the transport dynamics of TRWP-associated materials. Furthermore, measurable concentrations of 6PPD-Q were detected in runoff from both pavement types, demonstrating that urban roadway surfaces are important sources of tire-derived chemical contaminants.
A pronounced seasonal trend was also observed. Concentrations of 6PPD-Q detected during the late summer sampling period were significantly higher than those measured in early spring. This pattern suggests that elevated pavement temperatures and seasonal environmental conditions may enhance the accumulation, transformation, or release of tire-derived compounds on roadway surfaces. These findings highlight the importance of considering temporal variability when characterizing the environmental behavior of TRWP-associated contaminants.

4.24.P-We224 Fragmentation or Depolymerization? New Approach for Identifying Plastic Particles and Adsorbed Volatile Organic Compounds

Adèle Luthi-Maire[1], Mia Rondinelli[2], Sabhjeet Kaur[2], George diCenzo[2], Jesse Greener[3] and Julien Gigault[4] (1)Laval University, (2)Department of Biology, Queen's University, 116 Barrie Street, Kingston, Ontario, K7L 3N6, Canada, (3)Departement de Chimie, Université Laval, 1045 Avenue de la Médecine, G1V 0A6 Québec, Canada, (4)Takuvik International Research Laboratory, CNRS/Université Laval, 1045 Avenue de la Médecine, G1V 0A6 Québec, Canada

While the physicochemical degradation of plastic is increasingly documented the role of microorganisms in this process has not been widely studied. As interest grows in using bacteria to address plastic pollution, the detection of degradation products remains largely unexplored, the focus is on the discovery of new plastic-degrading bacteria and modifications to the original plastic. Preliminary studies have focused primarily on depolymerization where polymer chains are cleaved into smaller molecules, with little attention given to potential fragmentation into smaller particles. However, from a toxicological point of view and to completely understand the degradation pathways, the full size and shape spectrum of degradation products and molecules must be characterized. The lack of analytical methods to identify and characterize plastic markers at different scales following bacterial degradation clearly highlights this gap in understanding.
In this study, we experimentally initiated the biodegradation of polystyrene (PS) and polyvinyl chloride (PVC) by worms microbiota to develop an analytical method coupling thermos-desorption and pyrolysis with gas chromatography-mass spectrometry (Py-GC-MS) for the identification of specific biodegradation markers. A liquid-liquid extraction method, optimized in this method for both plastics, using dichloromethane was applied to microbiota cultures incubated with plastics. The extracted compounds, obtained in varying proportions, were then analyzed, according to predefined parameters, in thermodesorption for depolymerization products and pyrolysis for fragmentation. Thanks to this analytical strategy, we have revealed the existence of

depolymerization products derived from PS such as (2-phenylcyclopropyl)benzene, biphenyl and derived from PVC, some of which already known to be degradation products of other plastics have been detected, as well as additives as phthalic anhydre, 2-ethylhexan-1-ol or acenaphtene. Furthermore, the methods have identified novel molecules associated with biodegradation such as (1E)-1-benzylideneindene, 2-ethylcyclopentan-1-one and benzene. Concerning fragmentation, PS has been found in different quantities in samples whereas PVC was not present.
This method allows to detect plastic particles and volatile organic compound adsorbed on their surface, it can be used not only on biodegraded sample but also on different matrix susceptible to contain plastics and associated molecules.

4.24.P-We225 How Plastic-Associated Chemicals Travel the World: A Multimedia Mass-Balance Assessment To Quantify Emission Trends and Predict Environmental Concentrations of Bisphenol A

Judith Glienke[1], Chengkang Chen[1] and Frank Wania[1] (1)University of Toronto Scarborough

Bisphenol A (BPA) exemplifies the challenge of plastic-associated contaminants. It is used as a monomer in polycarbonate and epoxy resins, as a flame retardant in its brominated form, and as an additive in thermal paper and numerous plastic formulations. Thereby, it is released across the full product lifecycle from manufacturing through use and end-of-life waste management. As an endocrine disruptor widely detected across environmental compartments globally, BPA represents a compelling case study for understanding how plastic-associated chemicals move from products into the environment. Yet despite extensive monitoring, a coherent mass-balance accounting of global BPA releases has yet to be assembled.
We address this gap using an integrated modelling approach combining CiP-CAFE, a dynamic substance flow model, with BETR Global, a geographically explicit multimedia fate and transport model, to estimate BPA emissions to air, water, soil, and human skin across seven world regions from 2005 to 2024, and to predict resulting environmental concentrations. Modelled outputs were benchmarked against monitoring data from surface water, sediment, soil, and air across multiple regions.
Global BPA emissions grew substantially over the study period, with China and developing Asian countries accounting for half of annual global emissions by 2024. Emissions occurred predominantly during the use phase, followed by the end-of-life disposal phase, with landfilling, dumping, and inappropriate disposal driving disproportionate releases. Surface water received ~60% of annual global BPA emissions, while air and soil each received ~15%. Thermal paper and plastics using BPA as an additive were identified as the applications most responsible for environmental releases. Critically, in-use and in-waste stocks are growing rapidly, foreshadowing continued emission increases. Modelled concentrations were consistent with monitoring data across regions and compartments (ng/L in surface water, pg/L in air) supporting credibility of the emission estimates.
These results offer a temporally and spatially resolved emissions inventory and fate assessment that can directly inform exposure modelling, support source allocations for monitoring programmes, and strengthen the evidence base for regulatory risk assessment of BPA and structurally related plastic additives.

4.24.P-We226 Analysis of Floating Microplastics: From the Atmosphere to Lakes

Alessandra Cera[1], Ioanna Evalgelou[1] and Andreas Stohl[1] (1)University of Vienna

Atmospheric transport disperses microplastics (MPs) globally, and once deposited, these particles can contaminate terrestrial and aquatic ecosystems. In fresh waters, lentic systems could be especially sensitive to accumulating airborne MPs due to larger water surface and residence time than lotic systems, yet the magnitude of atmospheric deposition remains poorly constrained due to methodological limitations and little comparable data. This study aims to 1) analyse the relationship between the atmospheric bulk deposition of MPs and surface waters of lakes and ponds along gradients of anthropogenic pressures and 2) compare the measurements of MP atmospheric deposition with simulations of deposition fluxes and identify possible sources of emissions. We collected field measurements and performed simulations. We sampled MPs in atmospheric deposition and surface waters during summer 2025. Eight sites were selected: four spanning the outskirts to the centre of Vienna (~2 million inhabitants) and four in predominantly natural land use (high mountain, forest, plain). Two campaigns were conducted at each site in mid to late summer. Surface waters were sampled using a 10 µm mesh plankton net equipped with a flowmeter. Passive stationary samplers for atmospheric bulk deposition were deployed during the first campaign and retrieved during the second. Laboratory processing included digestion of organic matter and oleo-extraction, followed by µFTIR spectral identification. Quality assurance encompassed field and laboratory contamination controls, procedural blanks, and recovery assessments. Simulations were performed using the Lagrangian particle dispersion model FLEXPART using ERA5 and high-resolution data for traffic and population distribution, as proxy of tire wear and other MP emission sources. Preliminary analyses focus on (i) correlations between deposition loads and surface-water MP concentrations, (ii) differences between urban and natural sites, (iii) overlap in polymer spectra and particle morphologies between compartments, and (iv) verify the agreement between site-specific measured and simulated deposition fluxes, and potential geographical sources of emissions. Early findings from this study will contribute to clarify the extent to which airborne inputs drive MP contamination in lentic surface waters and inform the comparability of atmospheric and aquatic monitoring data and MP atmospheric deposition measurements and simulations.

Disclaimer/Disclosure: Funded by Horizon Europe under Marie Sklodowska-Curie Actions, project "FLOAT", grant agreement ID 101150279.

4.24.P-We227 Creating a Database of Tire Rubber Chemical Markers for Improved Mass-Based Quantification of Tire Wear Particles

Kayli Paterson[1], Diana Lin[1], Elisabeth Rødland[2], Kelly Moran[3] and Rebecca Sutton[1] (1)San Francisco Estuary Institute, (2)Norwegian Institute for Water Research (NIVA), (3)San Francisco Estuary Institute (SFEI)

Tire wear particles (TWPs) are the most prevalent type of microplastics found in environmental stormwater samples and the most abundant type found in the San Francisco Bay (California, USA). Microplastic monitoring is generally difficult, with methods often being size or material-dependent. TWPs have been largely ignored by general microplastic methodologies due to their difficulty of assessment with spectrographic instruments. Quantification of tire wear particle mass via pyrolysis gas chromatography–mass spectrometry (Py-GC-MS) analysis for multiple tire rubber chemical markers can be used to estimate mass-based tire chemical marker concentrations in environmental samples. While tire chemical marker reference databases have

been developed for Norway and Australia, no equivalent representative database of this type currently exists in the United States. Because tire rubber composition varies due to brand, vehicle type, local weather, and intended use, creating a representative regional tire database is important for improving the accuracy of estimated tire wear concentrations in environmental samples. The San Francisco Estuary Institute, in partnership with the Norwegian Institute of Water Research (NIVA), is working to create a tire chemical marker reference database that is representative of tires used in the San Francisco Bay Area. To develop a reference database, thirty tires representing popular passenger vehicles, light trucks/SUVs, and commercial/heavy-duty vehicles were sampled in triplicate and analyzed using Py-GC-MS for various tire markers previously identified by NIVA. This reference database will be made publicly available to support the broader assessment of TWPs in environmental samples. This database can also be used to create mass-based road runoff profiles for use in modeling and regulatory applications.

4.24.P-We228 Microplastics and Plastic-Related Contaminants in Canadian Arctic Atmospheric Deposition: Co-Occurrence and Limited Microplastic-Chemical Associations

Alejandra Granados Galvan[1], A. H. M. Enamul Kabir[1], Amila De Silva[2], Liisa Jantunen[2], Derek C.G. Muir[2], Huixiang Xie[1], Youssouf Djibril Soubaneh[1], Peter Amarualik Sr.[3] and Zhe Lu[1] (1)University of Quebec at Rimouski (UQAR), (2)Environment and Climate Change Canada (ECCC), (3)Resolute Bay

Plastic pollution affects remote ecosystems through both plastic particles and related chemicals. Atmospheric deposition can deliver microplastics (MPs, 1 μm-5 mm) and contaminants to terrestrial and aquatic environments, but this process remains poorly understood in the Canadian Arctic. Although MPs can carry chemicals, it is unclear whether MP abundance reflects contamination by these chemicals in Arctic atmospheric deposition.

Surface snow and bulk atmospheric deposition samples were collected from Canadian Arctic and subarctic sites during 2020-2021: Little Fox Lakes (YK; n=6), Yellowknife (NT; n=5), Cornwallis Island (CI; n=9), and Alert (AL; n=15). These samples were analyzed for MP abundance and for concentrations of per- and polyfluoroalkyl substances (PFAS), organophosphate esters (OPEs), and benzotriazole ultraviolet stabilizers (BZT-UVs). CI had the highest ΣPFAS (3.5±1.1 ng/L), ΣOPEs (97.4±30.5 ng/L), and MPs (50±31 n/L) among the four sites, but differences were not significant. YK had the highest ΣBZT-UVs (1.4±1.7 ng/L), while NT had the lowest ΣBZT-UVs and MP (0.2±0.2 ng/L, 12±7 n/L). PFAS were dominated by PFBA, PFHxA, PFHpA, PFNA, and sulfonates PFBS, PFECHS; OPEs by TCPP, TBOEP, TDCPP, TPPO, and TEP; and MPs by polypropylene and polyester.

MP abundance was not positively correlated with PFAS, OPE, or BZT-UV concentrations, whereas TCPP and TEP showed negative associations with MPs. These results suggest that MP abundance may not be a reliable indicator of plastic-related chemical contamination in Arctic snow. Under cold winter conditions, lack of contaminants' association likely reflects differences in emission sources, atmospheric transport pathways, or deposition behaviours rather than major chemical losses (e.g., volatilization, degradation) after deposition. Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) analysis showed that winter air masses at CI and AL were mainly confined to the High Arctic, while spring air masses had broader Arctic influence. At YK and NT, Pacific westerlies and North American air masses dominated, possibly transporting MPs and the related contaminants.

Our results show that these contaminants can co-occur in Arctic atmospheric deposition, but MPs are not positively associated with PFAS, OPEs, and BZT-UVs. These findings highlight the need to assess MPs'

abundance and plastic-related contaminants together, without assuming that one reliably indicates the other in Arctic atmospheric deposition.

Disclaimer/Disclosure: We appreciate the scholarships provided by the Fonds de recherche du Québec, including Scholarships PBEEE 334561 and B2X 331680, as well as by the Centre de recherche en écotoxicologie du Québec (EcotoQ) and UQAR-ISMER.

4.24.P-We229 Method Development and Monitoring for Widespread Plastic Additives in Coastal Urban Waters

Lizzie Miller[1] and Jiehong Guo[1] (1)MTU

One concern regarding plastic waste is its release of leachate containing additives which leak into waterways and surrounding environments. Plastic additives are chemicals which assist in the physiochemical properties of plastic: improving durability, flexibility, flame retardancy, or resistance to UV degradation, among other benefits. Typically, these compounds bond non-covalently to plastic, increasing their susceptibility to leach into the surrounding environment, food, or drinking sources. However, approaches to investigating these broad classes of compounds limit our understanding on the extent of their presence near urban areas. Plastic additives were monitored in grab water samples collected during 2025-2026 from San Francisco Bay, which is impacted by urban runoff and wastewater discharges. A methodology has been developed to analyze up to 120 plastic additives, including bisphenols, organophosphates, antioxidants, phthalates, and UV stabilizers. Aqueous samples were filtered, purified by solid phase extraction, and quantified by high performance liquid chromatography tandem mass spectrometry. The data collected using this method will be used to determine spatial and temporal trends of these pollutants in San Francisco baywater and stormwater. Findings from this study will improve understanding of the fate of plastic additives in San Francisco Bay and support risk assessment and environmental management strategies.

4.24.P-We230 Trend Analysis of Environmental Concentrations of Bisphenol A in North American Surface Waters

Elaine Jennings[1], Javier Soto[2], Simon Gutierrez[1], Margaret (Meg) McArdle[3], Ellen Mihaich[4], Evelyn Majoris[5] and Michael Bunge[5] (1)Ricardo-AEA Ltd, (2)Ricardo-AEA Ltd., (3)Exponent, (4)ER2, (5)Covestro Deutschland AG

Bisphenol A (BPA) is a high production volume chemical that has been in commercial production for over sixty years. BPA has been detected in surface waters and sediments since the mid-1990s. Concerns over the endocrine active properties of BPA and other bisphenols have prompted increased regulatory scrutiny. Understanding long term trends of BPA concentrations in surface water and sediments is critical for assessing the effectiveness of risk management measures and identifying remaining environmental concerns. This study evaluates spatial and temporal trends of surface water and sediment BPA concentrations in freshwater and saline systems across North America. A database was compiled from peer-reviewed literature and public monitoring programs, yielding 4,041 concentration records from 703 sites sampled between 2005 and 2025. Data quality was independently assessed using the Criteria for Reporting and Evaluating Exposure Datasets (CREED) framework to support robust statistical analysis. Temporal trends were analyzed using Mann–Kendall trend test with Sen's slope estimation and ordinary least squares (OLS) regression. Analyses were conducted at

continental and hydrologic unit scales. Most data were found for freshwater, followed by freshwater sediment, saline sediment, and saline water. BPA concentrations in freshwater declined from 2010– 2017, with the 95th percentile dropping from 992 to 47 ng/L (>95% decrease) and the 50th from 52.45 to 38.06 ng/L. Freshwater results show a clear, statistically significant, and widespread decline in BPA concentrations. At the continental scale, the Mann–Kendall test indicates a strong negative Sen's slope of −0.061 ng/L per year ($p<<<0.05$), with an OLS coefficient of -0.014 confirming a significant downward trend ($p=0.026$). Trends were most pronounced in the Great Lakes region, which represents nearly half of the dataset and includes several intensively monitored basins. Freshwater sediment data are inconsistent; some regional data show increases, while some show decreases. Data are lacking for saline water and saline sediment for robust trend analysis. Overall, the findings demonstrate substantial reductions in BPA concentrations in North American surface waters over the past decade, indicating broad progress in reducing exposure. We encourage continued monitoring of BPA, including sediment sampling and source tracking where some local trends suggest a possible increase in BPA concentrations.

Disclaimer/Disclosure: This work was funded by the American Chemistry Council's BPA Global Alliance.

4.24.P-We231 Understanding Polymer-Specific Interactions Between Microplastic and Organic Micropollutants: Why a Closer Look Matters

Frederik Funk[1] and Karolina Nowak[1] (1)Environmental Geochemistry, Institute for Integrated Natural Sciences, University of Koblenz

Microplastics (MPs) are a diverse group of synthetic or semi-synthetic organic polymers measuring less than 5 mm in size, which occur almost ubiquitous in the environment. Besides their own potential hazardous effects, MPs adsorb persistent organic pollutants (POP), which leads to additional risks regarding their combined toxicity and their potential to act as vectors into organisms.

So far, investigations on the interaction of MPs with POPs in environmental samples are lacking a distinction between different microplastic types. This is particularly relevant given the vast differences of MPs in hydrophobicity, porosity, roughness, additives and charge. All these aspects may influence the composition and amount of POPs sorbed to MPs as well as their relevance in risk assessments.

To address this critical knowledge gap, MP identification is combined with a polymer-specific separation step and non-target analysis (NTA) for pollutants using gas chromatography–mass spectrometry (GC-MS). In the first approach, the environmental MP samples will be collected from the Rhine River in Germany. This enables the determination of the composition of the sorbed micropollutants, which in turn allows potential sources to be identified. The most prevalent MPs type will be further chosen for a second approach.

In order to assess whether the binding of POPs to MPs occurs primarily in the river itself or whether the MPs enter it already mostly loaded, pure reference MPs will be placed in sample holders, which will be put in the Rhine. In rivers, inorganic and organic particles are still far more prominent than MP itself. To compare the relevance of MP, additional holders will be filled with sand and humic acid coated particles as proxies and analysed by NTA as well. In the final phase, specific sorption coefficients of the most prevalent pollutants in the NTA approach will be determined in batch tests for all previously mentioned adsorbents.

Based on these experiments, the relevance of different MPs types as vectors for POPs can be evaluated. This will improve our understanding of the role of this process for bioaccumulation and pollutant uptake in the food chain. Future studies can use the obtained data for model adjustment and to set up more detailed experiments resembling real environmental conditions on combined toxicological effects on freshwater organisms.

4.24.P-We232 Investigation of the Absorption and Accumulation Characteristics of 6PPD-Q in Leafy and Root Vegetables Under Hydroponic Conditions

Kazuki Sugawara[1], Yusuke Oda[1], Towa Sumikawa[1] and Junko Hara[2] (1)The University of Kitakyushu, (2)Agency of Industrial Science and Technology

6PPD-quinone (6PPD-Q), a substance formed through the oxidation of the antioxidant 6PPD found in tire wear particles, has been identified as the causative agent for mass die-offs of coho salmon. Consequently, there is an urgent need to promptly assess its health risks to other organisms. This study investigated the dietary risks to humans by evaluating the absorption and accumulation behaviors of 6PPD-Q in four leafy vegetable species (lettuce, Chinese cabbage, cabbage, and spinach) and three root vegetable species (Japanese radish, onion, and carrot) cultivated under laboratory hydroponic conditions with a nutrient solution containing 6PPD-Q. The overall trend indicated that root vegetables tend to absorb and accumulate higher concentrations of 6PPD-Q than leafy vegetables. On the other hand, the translocation from below-ground parts (roots) to above-ground parts (shoots) varied significantly among the plant species. Among the species examined, spinach and onion exhibited a high proportion of translocation from below-ground to above-ground parts. Considering the dietary ingestion risk of 6PPD-Q, concentrations tend to be higher in root vegetables than in leafy vegetables. Therefore, clarifying the detailed accumulation mechanisms for each plant species in future studies will lead to more precise and accurate risk assessments.

4.24.P-We233 Assessing Capture of Microplastics in Biodeposits by Caged Eastern Oyster (Crassostrea virginica) in an Urban Tidal Creek

Barbara Beckingham[1] and Jon Daniel[1] (1)College of Charleston

Microplastics are a complex mixture of anthropogenic, synthetic polymer particles <5 mm in size of differing sizes, shapes, and chemical composition that are pervasive in the environment. Solutions to both reduce emissions and remove them from aquatic environments are needed. Filter-feeding bivalves have been proposed as a nature-based solution since they have been shown in previous studies to capture microplastics from water and deposit them in biosolids. The eastern oyster (Crassostrea virginica) is widely distributed throughout the east coast of the United States and likely contribute to enhanced sedimentation of microplastics via their feeding activities where they reside. We will present results of a pilot study that designed floating cages with cellulose bags suspended beneath to capture settling particulates and deployed from a deep-water dock in an urban tidal creek. Biodeposits captured from three cages containing aquaculture triploid oysters will be compared to particulates captured in control cages containing only oyster shells. Water samples will be collected daily during the deployment to assess the level and variety of microplastics present. Water and biosolid samples will be digested and analyzed for microplastics (target >50 micron) by stereomicroscopy and Raman spectroscopy. We hypothesize that the modified cage systems containing C. virginica will capture more microplastics than control cages and that, in comparison to microplastics found in surface waters, oysters will demonstrate selectivity by

microplastic size and shape. Rates of microplastic deposition will be used to evaluate the role that C. virginica may play in the fate of microplastics in tidal creek systems and the potential for caged oysters to contribute to nature-based solutions to microplastic pollution.

4.24.P-We235 Unraveling the Combined Effect of Acidification and Microfibers From Textiles on Vital Prey Species

Lauren Kashiwabara[1], Lisa Hildebrand[1], Leigh Torres[1], Stacey Harper[1] and Susanne Brander[1] (1)Oregon State University

Microfibers are the most common anthropogenic microparticle morphology found in environmental samples and originate from natural (i.e., cotton) and synthetic (i.e., polyester) textiles. Microfiber toxicity is complicated by fiber type, chemical additives (e.g., dyes and softeners), and weathering. These factors may interact to affect organisms, especially in marine systems impacted by climate change stressors, such as acidification. Marine zooplankton, such as mysid shrimp Holmesimysis sculpta, are vulnerable to climate change, with decreasing populations having implications for food webs. Understanding microfiber toxicity and climate change is essential for assessing ecological risks and informing sustainable textile practices. We are investigating microfiber toxicity in field-collected (H. sculpta) mysids, and comparing their sensitivity to Americamysis bahia, a lab model sensitive to microfibers. To examine the complexities of microfiber toxicity, we exposed juvenile A. bahia to polyester, cotton, or dyed cotton that was untreated or treated with a commercial softener or eco-softener and a subset of their leachates. After a 7-day exposure, mysids underwent an acute ocean acidification trial before growth and behavioral analyses. Growth was only impacted in mysids exposed to pristine commercial softener-treated cotton compared to its polyester counterpart. However, cotton that had not been dyed, regardless of softener type or weathering, did not have an impact on behavior. Dyed cotton had a different behavioral response, where activity was dependent on the addition of the commercial softener and weathering. While in pristine polyester treatments, we only observed behavioral impacts when treated with either eco or commercial softeners and saw the opposite effect in weathered conditions, where only the non-treated polyester displayed impacts. These responses, including in low pH or leachate-exposed organisms, indicate interactions between softeners, dyes, and weathering. To connect our laboratory model, we conducted 48h microfiber exposures with weathered commercial softener-treated polyester and adult A. bahia and found that their behavior was not impacted, indicating native mysids are more sensitive than their model organism counterpart. Together, these results will allow us to assess how microfibers and climate change may impact the quality of a vital prey species and unravel the variables associated with microfiber toxicity and textile production.

4.24.P-We236 Effects of Polypropylene Microplastics on the Growth of Carp and Marine Amphipods: Toxicity Changes Due to Material History and UV Weathering

Kei Nakayama[1], Seiichi Uno[2], Masatoshi Yamasaki[2], Emiko Kokushi[2], Kosuke Tanaka[3], Yusuke Takahashi[4], Shinpei Wada[5], Osamu Kurata[5], Atsuko Amano[4], Takuya Itaki[4] and Go Suzuki[3] (1)Ehime University, (2)Kagoshima University, (3)National Institute for Environmental Studies, (4)National Institute of Advanced Industrial Science and Technology, (5)Nippon Veterinary and Life Science University

This study evaluated the growth-inhibitory effects of polypropylene (PP) microplastics. Prior to the exposure experiments, distinct PP samples were prepared to investigate differences driven by material history (virgin vs.

recycled), particle size (<106 μm vs. <300 μm), and ultraviolet (UV) weathering. A subset of virgin PP was subjected to artificial UV irradiation to simulate environmental weathering.
Using these PP samples, experiments were conducted on common carp (Cyprinus carpio) and marine amphipods (Ptilohyale barbicornis). Carp were subjected to a 28-day dietary exposure following a 7-day acclimation. A 10% in diet exposure concentration was used to compare virgin and recycled PP, while lower concentrations (2.1% and 4.5%) were used to assess UV-irradiated PP. Specific growth rates (SGR) of the carp were subsequently evaluated. Similarly, the amphipods were exposed to the PP samples for 14 days to assess the effects on their growth.
In carp, untreated virgin PP significantly reduced SGR compared to controls. Conversely, no significant growth reduction was observed with recycled or UV-irradiated PP. While statistical comparisons of these mitigating effects across independent trials were marginally non-significant ($p = 0.301$ for virgin vs. recycled; $p = 0.061$ and $p = 0.056$ for the 2.1% and 4.5% UV groups, respectively), a consistent trend of reduced toxicity emerged. In amphipods, virgin PP caused significant growth inhibition, yielding a lowest observed effect level (LOEL) of 0.2% in diet regardless of particle size. In contrast, recycled PP exhibited attenuated toxicity, shifting the LOEL to higher concentrations (1% or 5%). Furthermore, UV irradiation significantly altered dose-response patterns. Particle size alone did not significantly affect toxicity in either species.
These results indicate that PP microplastic toxicity is influenced by material history. The attenuated toxicity in recycled and weathered PP might be related to altered chemical properties, possibly due to the loss of toxic additives and unreacted monomers during thermal or environmental processes. Therefore, it is necessary to consider these diverse material histories in ecological risk assessments, rather than relying exclusively on pristine virgin plastics.

Disclaimer/Disclosure: This research was supported by the Environmental Research and Technology Development Fund (No. 1-2204: JPMEERF20221004) of the Environmental Restoration and Conservation Agency and the Ministry of the Environment of Japan.

Plastics and Plastic-Associated Contaminants as Environmental Mixtures: Monitoring, Fate, Effects and Interactions

4.24.V-01 Contaminants of Concern: Metal and Microplastics in Environmental Water Bodies Near DKU

Jingran Ding[1], Aizhen Kuang[1] and Floyd Beckford[1] (1)Duke Kunshan University, Division of Natural and Applied Sciences

Microplastic pollution is increasingly recognized as a pressing environmental issue not only because of its persistence in aquatic ecosystems but also its capacity to act as a medium for other contaminants such as heavy metals. This study examines microplastic contamination and composition in water bodies near DKU and explores their interactions with heavy metals in water and sediment, offering insights that could guide future monitoring and waste management strategies.
Water samples were collected from nine sites selected for their location and hydrological relevance, while six corresponding sediment samples from selected sites were obtained to capture pollutant accumulation trends. All samples underwent microwave acid digestion, and subsequent quantification of elemental pollutants was

conducted through Inductively Coupled Plasma Mass Spectrometry (ICP-MS). This enabled the detection and profiling of multiple heavy metals, including Fe, Zn, Cu, Pb, Cd, and Hg, across both water and sediment matrices. In addition, future analysis on the cation exchange rate of the sediments will be integrated into the dataset. Parallel efforts are underway to isolate and characterize microplastics using infrared microscopy and spectroscopy to determine polymer type, morphology, and size distribution.
ICP-MS analysis of the target metal ions revealed higher concentrations in sediments than in water. Moreover, the elemental profiles across both matrices were similar in type but different in magnitude among sites, suggesting potential pollution sources including domestic discharge and surface run-off. The results to date do not indicate contamination levels above regulatory standards, although further analysis of microplastic characteristics will be necessary to fully understand pollutant interactions.
This research establishes a framework for integrated detection of microplastics and heavy metals in local aquatic systems. By identifying sediment as a reservoir for contaminants, our work supports advanced understanding of pollutant distribution and dynamics.

Small Molecule, Big Questions: Precursors, Pathways and Planetary Reach of Trifluoroacetic Acid

4.25.T-01 Analytical Strategies for the Determination of TFA Across Environmental and Food Matrices

Carlos Bueno[1], Simon Roberts[1], Craig Butt[1], Sam Lodge[2] and Holly Lee[1] (1)SCIEX, (2)Phenomenex

Ultrashort-chain perfluoroalkyl acids (PFAAs), such as difluoroacetic acid (DFA), trifluoroacetic acid (TFA), perfluoropropanoic acid (PFPrA), perfluoromethane sulfonic acid (PFMS), perfluoroethane sulfonic acid (PFEtS) and perfluoropropane sulfonic acid (PFPrS), represent a subset of PFAS that are characterized by a chain length of 1–3 perfluorinated carbons. Compared to their longer-chain counterparts, these chemicals have historically been overlooked due to their presumed lower toxicity and bioaccumulation potential. However, the high polarity, water solubility and persistence of these ultrashort-chain PFAAs can lead to accumulation in aquatic and plant environments, resulting in increased exposure for aquatic organisms and humans. In particular, TFA has been reported in numerous matrices worldwide, often at concentrations orders of magnitude higher than those of the longer-chain PFAAs. There is limited environmental data on ultrashort-chain PFAAs due to analytical challenges. Previous evaluations of HILIC and reverse-phased chromatography have reported issues such as poor retention and separation, matrix effects and limited analyte range. In contrast, mixed-mode chromatography combining reversed-phase and ion-exchange functionalities has demonstrated promising results for ultrashort-chain PFAAs. Here, we present different analytical strategies developed for the quantitation of ultrashort-chain PFAS, particularly TFA, in drinking and environmental water matrices, beverages and assorted food matrices. Excellent chromatographic separation and quantitative performance with matrix-specific limits of quantitation in the sub-to-low ppt range were achieved using a mixed-mode stationary phase and a high-end triple quadrupole mass spectrometer. The ubiquity of TFA in the laboratory environment also necessitates consumables screening, automated sample preparation and novel delay column strategies, which will also be discussed as measures to mitigate background contamination. These findings are critical to the inclusion of TFA and other ultrashort-chain PFAS in the development of new methods tailored to region-specific regulations and matrices in understanding their source attribution.

4.25.T-02 Persistence, Defluorination, and Oxidative Trifluoroacetic Acid Formation in the Aqueous Direct Photochemistry of Aryl-CF3 Compounds

Zhefei Guo[1], Geneviève Tremblay[1], Rylan Lundgren[1] and Shira Joudan[1] (1)University of Alberta

The trifluoromethyl group (CF3) is widely incorporated into pharmaceuticals and agrochemicals, most cases as aryl-CF3, to modulate physicochemical and pharmacokinetic properties. However, the environmental transformation of aryl-CF3 compounds remains poorly understood. These compounds fall within the OECD definition of PFAS and may act as precursors to trifluoroacetic acid (TFA), a persistent and mobile terminal product increasingly detected in the environment. Here, we investigate the aqueous direct photochemistry of aryl-CF3 compounds with varied substitution patterns, focusing on the competition between defluorination and TFA formation. Substituent electronic properties and position jointly influence both reactivity and reaction pathways. Electron-donating groups promote phototransformation and favor defluorination, particularly at non-para positions, whereas para-substituted molecular topology more readily accesses CF3-retaining pathways leading to TFA. Across 24 aryl-CF3 compounds tested, 14 were found to produce TFA under aqueous direct photochemistry. Notably, all tested aryl-CF3 pharmaceuticals and agrochemicals formed TFA, with molar yields ranging from 0.54% to 6.9% under our experimental conditions. Mechanistic experiments indicate that TFA formation is governed by oxidative conditions: it remains minor under direct photochemistry and can increase in the presence of external oxidants. These findings establish structure-reactivity relationships for understanding aryl-CF3 aqueous photochemistry and reveal that promoting defluorination over CF3 retention helps reduce TFA formation. More broadly, our results may inform the green design of fluorinated molecules that harness CF3 functionality while exhibiting reduced environmental persistence.

4.25.T-03 Gaseous Perfluorinated Carboxylic Acids and Their Deposition in Québec Dominated by Trifluoroacetic Acid (TFA)

Trevor VandenBoer[1], Irina Nistorescu[1], Daniel Persaud[1], Alessia Colussi[1], Eric Vanhauwaert[1], Alexander Kasperkiewicz[2], Chuba Shunthirasingham[3], Hayley Hung[4] and Cora Young[1] (1)York University, (2)University of Toronto, (3)No Affiliation, (4)Environment and Climate Change Canada (ECCC)

Atmospheric oxidation of volatile perfluorinated alkyl substances (PFAS) is a major source of gaseous perfluorinated carboxylic acids (PFCAs). Their abundance and deposition after formation controls their subsequent impacts on the global environment. For example, atmospheric formation leads to observed parts-per-trillion mixing ratios of TFA in the gas phase, as well as ug L-1 concentrations in Arctic ice caps. There are numerous precursors that can form mostly short chain PFCAs (C6 or smaller) through atmospheric oxidation, including chlorofluorocarbon replacements.

Active atmospheric sampling methods for PFCAs have the potential for substantial analytical artifacts (e.g. blown on or blow off interferences) and are yet to be subject to rigorous validation experiments, such as calibration with gaseous analytes or method intercomparisons3. Passive sampling methods have similar limitations and have treated PFCAs as traditional persistent organic pollutants instead of targeting their acid functionalities to elicit method specificity, generally to collect a broader range of atmospheric PFAS and other hazardous atmospheric pollutants distributed between both the gas and particulate phases.

As a result, insights into the abundance, phase distribution, and spatial and temporal variability of atmospheric

PFCAs has been limited. Here we demonstrate a calibrated passive sampling technique for gaseous PFCAs based on long-established acid sampling strategies for traditional pollutants (e.g. nitric acid, HNO3) using nylon filters in a low cost diffusion-driven sampler. These were deployed in several large field campaigns in Canada from weeks to months timescales to study controls on PFCA formation and fate, including two iterations of Canada's Whales Initiative that included deployments along the St. Lawrence River. Simultaneous determinations of wet and total deposition as removal processes to the surface now give increasing insight into the role of the atmosphere in the global transport of TFA.

4.25.T-04 TFA Formation and Deposition via Gas-Phase Oxidation of HFCs and HFOs: Insights From HFC-134a and HFO-1234yf

Rayne Holland[1], MD ANWAR HOSSAIN KHAN[1] and Dudley Shallcross[1] (1)University of Bristol

Concerns around the prevalence of trifluoroacetic acid (TFA, CF3COOH) in the environment have been ongoing for over 20 years. One source of TFA to the environment is via the atmospheric degradation of fluorinated gases (F-gases) to TFA and its subsequent deposition. During the last decade, controls on one major class of F-gases, hydrofluorocarbons (HFCs), has resulted in an increase in the production and use of hydrofluoroolefins (HFOs) which often generate TFA at faster rates and at higher yields. As such, it is vital to monitor the impacts of this transition. Here, a tropospheric chemical transport model, STOCHEM-CRI, is used to compare the amount of TFA generated by the breakdown of an abundant HFC, HFC-134a (1,1,1,2-tetrafluoroethane, CF3CH2F), and its typical replacement, HFO-1234yf (2,3,3,3-tetrafluoropropene, CH2=CFCF3). Using derived global emissions estimates for 2023, we predict that HFO-1234yf is already dominating atmospheric generation and deposition of TFA over Europe when compared with HFC-134a. This is despite the fact that derived global emissions of HFC-134a are 22 times higher than those of HFO-1234yf. Globally, our simulations show that TFA production from HFO-1234yf is already equivalent to 26-75% of the TFA production from HFC-134a. As the transition away from HFCs progresses, it is likely that HFO-1234yf will continue increasing in its global contribution to TFA generation and resultant environmental contamination. Application of this approach to additional HFCs and HFOs is limited by poorly constrained TFA yields. Here, we report preliminary TFA yields for a range of HFCs and HFOs derived via explicit chemical mechanism modelling.

4.25.T-05 Real-Time Measurement of Trifluoroacetic Acid in the Atmospheric Gas and Particle Phase in Toronto

Mayre Rodriguez Ramirez[1], Eric Vanhauwaert[1], Sadeya Nader[1], Yashar Ebrahimi-Iranpour[1], Olivia Driessen[2], Nasrin Dashti[1], RenXi Ye[1], Daniel Persaud[1], Irina Nistorescu[1], Na-Yung Seoh[1], Jessica Clouthier[1], Jennifer Murphy[2], Cora Young[1] and Trevor VandenBoer[1] (1)York University, (2)University of Toronto

Perfluorocarboxylic acids (PFCAs) are a subgroup of poly- and perfluoroalkyl substances (PFAS) that have a fully fluorinated chain attached to a carboxylic acid. PFCAs with carbon chains longer than 6 carbons have been demonstrated to be stable, toxic, and bioaccumulative, and therefore have received more attention; nonetheless, ultra short-chain PFCAs, and especially trifluoracetic acid (C2, TFA), remain largely overlooked. TFA has been found at increasing concentrations in different matrices, including human specimens, and although it is not bioaccumulative, its persistence and our chronic exposure to high concentrations can pose a health risk to humans and the environment.

TFA can enter the atmosphere through photochemical oxidation of PFAS or direct emissions, and its dominant atmospheric sinks are wet and dry deposition. Given the reported low pKa and Henry's law constant of TFA, and the low aerosol pH and liquid water content (LWC) field estimations, TFA predominates in the gas phase before it partitions to the condensed phase. Quantitative direct measurements of atmospheric TFA are challenging as they're subject to artifacts in sampling and analysis. The separation of gaseous and particulate TFA is necessary to avoid acid displacement bias, but it is also difficult, and the few existing methods are limited to weekly or longer timescales.

We developed a new online technique to simultaneously measure TFA in the gas and particle phase at hourly time resolution using an ambient ion monitor coupled to an ion chromatograph and a single quadrupole mass spectrometer (AIM-IC-MS). This new method can simultaneously measure gaseous and particulate TFA at one-hour timescales, alongside a full suite of major atmospheric anionic and cationic species needed to model the partitioning system.

In this study, we present hourly measurements of TFA in ambient gases and particles (<2.5μm) from the Toronto Halogens, Emissions, Contaminants, and Inorganics eXperiment (THE CIX) campaign in Toronto in summer 2023. Correlations of diurnal variations with ozone production and air temperature provide evidence of atmospheric formation. Comparisons with previous low- and high-time resolution measurements in the gas phase show comparable concentrations. Observations are compared to thermodynamic gas-particle partitioning and to deposition fluxes calculated from precipitation samples.

4.25.T-06 Understanding Interactions Between Atmospheric Trifluoroacetic Acid and Surfaces

Nasrin Dashti[1], Emma McLay[1], Mayre Rodriguez Ramirez[1], Trevor VandenBoer[1] and Cora Young[1] (1)York University

Trifluoroacetic acid (TFA), the smallest member of the perfluoroalkyl carboxylic acid family (PFCAs), is a terminal degradation product of many per- and polyfluoroalkyl substances. All TFA will be removed from the atmosphere by wet and dry deposition. Detections of PFCAs in remote regions suggest that additional processes may contribute to their atmospheric fate. While heterogeneous uptake is known to affect several strong atmospheric acids, its role in the atmospheric fate of TFA remains unclear. Atmospheric measurements conducted in Toronto detected TFA in both aerosols and urban grime, where the latter is the chemically complex films found on impermeable urban surfaces. To our knowledge, this represents the first report of TFA in urban grime. These observations prompted further investigation into the processes governing the occurrence of TFA on atmospheric particles and urban surfaces. To better understand these processes, laboratory studies were conducted using atmospherically relevant aerosol proxy substrates. TFA uptake was observed on all investigated substrates and was strongly substrate dependent, with evidence of reactive uptake observed on several substrates. Together, the field observations and laboratory results suggest that interactions with aerosols and urban surfaces may influence the atmospheric transport and fate of TFA beyond predictions based solely on equilibrium gas-particle partitioning.

Small Molecule, Big Questions: Precursors, Pathways and Planetary Reach of Trifluoroacetic Acid

4.25.P-Th191 CF3 Pesticide Usage in Canada: Current Knowledge and TFA Formation Potential

Geneviève Tremblay[1], Mark Hanson[2], Jonathan Challis[3] and Shira Joudan[1] (1)University of Alberta, (2)University of Manitoba, (3)Agriculture and Agri-Food Canada (AAFC)

There is more trifluoroacetic acid (TFA) in the environment than can be accounted for by known emissions. While fluorinated heat-transfer fluids are well-characterized precursors to TFA, other CF3-containing contaminants are poorly understood as potential precursors. In Canada, over 100 million kg of pesticides were used in 2023, with potential to enter water systems. A subset of these contain alkyl or aryl-CF3 functionality. It remains an ongoing question as to the degree of TFA formation from CF3-containing pesticides. While several studies have estimated TFA formation from pesticide use in the USA, Europe, and China, there is a lack of data describing the contribution of these fluorinated pesticides in Canada and to the global TFA burden. Here, we evaluate current and historical Canadian pesticide usage data to present an in-depth TFA formation potential. A thorough review of transformation data under metabolic, atmospheric, and aquatic conditions are compiled and presented in order to highlight pesticides of interest and gaps in current knowledge from a Canadian perspective.

4.25.P-Th192 Heterogeneous Uptake and Release of Gas-Phase Trifluoroacetic Acid on Aerosol Proxy Surfaces

Nasrin Dashti[1], Elizabeth Gaona-Colmán[1], Cora Young[1] and Trevor VandenBoer[1] (1)York University

Perfluoroalkyl carboxylic acids (PFCAs, CnF2n+1 COOH), including ultrashort-chain compounds such as trifluoroacetic acid (TFA), are considered terminal degradation products of many volatile per- and polyfluoroalkyl substances (PFAS) found in the atmosphere. TFA is a strong acid (pKa = 0.52) and is highly stable under environmental conditions, with estimated environmental lifetimes on the order of centuries to millennia. TFA is primarily formed through the atmospheric degradation of volatile fluorinated compounds, including hydrochlorofluorocarbons, saturated hydrofluorocarbons, and unsaturated hydrofluoroolefins, which are extensively used as refrigerants and foam-blowing agents. PFCAs are generally assumed to behave similarly to other strong atmospheric acids, favouring rapid partitioning into condensed phases. However, the contribution of aerosols to the atmospheric behaviour of PFCAs remains poorly understood. PFAS have been detected in remote regions, including the Arctic, highlighting their long-range transport potential. Because ionic PFCAs are nonvolatile and highly soluble, indirect transport pathways, including association with aerosols, are likely important. Field observations linking PFCA deposition with known mineral components of dust further motivate the investigation of aerosol-mediated PFCA transport. PFCA–aerosol interactions are commonly assumed to be governed by equilibrium gas–particle partitioning, yet recent modelling studies underestimate PFCA concentrations observed in aerosols. This discrepancy suggests that additional processes, such as heterogeneous or reactive uptake on particle surfaces, may influence PFCA partitioning and atmospheric fate. This study aims to investigate the uptake of gas-phase TFA onto aerosol proxy substrates using a coated-wall flow tube reactor coupled to a negative-ion proton-transfer chemical ionization mass spectrometer (NI-PT-CIMS) under both dry and humid conditions at room temperature. Uptake was examined on proxy surfaces

representing mineral dust, sea salt, and secondary inorganic aerosols. Results under dry conditions indicate higher uptake of gas-phase TFA on mineral dust proxy surfaces compared to sea salt proxies, whereas experiments conducted at 50% relative humidity show higher uptake coefficients for mineral dust proxy surfaces. These observations suggest that association with aerosol may facilitate long-range atmospheric transport of ultrashort-chain PFCAs to remote regions.

4.25.P-Th194 Ultrashort-Chain PFAS in Rhode Island Drinking Water Sources

Kelsey Staniec[1], Jitka Becanova[1], Simon Vojta[1] and Rainer Lohmann[1] (1)University of Rhode Island

Ultrashort-chain per- and polyfluoroalkyl substances (PFAS) are historically understudied relative to their longer-chain counterparts due to their inability to be quantified using standard PFAS extraction methods. Recently, these compounds, particularly trifluoroacetic acid (TFA), have been found to be ubiquitous in many environmental media. This study sought to quantify five ultrashort-chain PFAS compounds (TFA, PFPrA, TFMS, PFEtS, PFPrS) in drinking water source sites across Rhode Island. 280 samples were collected during the time period from summer 2024 to spring 2025. These samples were then measured via direct injection onto an HPLC-MS instrument. Of the compounds of interest, only TFA and TFMS were consistently detected. TFA was present in 62% of samples at concentrations ranging from <50ng/L to >4000ng/L. TFMS was detected in 25% of samples at concentrations <100ng/L. The remaining compounds were only detected in <5% of samples. These samples were also tested for 40 legacy PFAS and their precursor compounds, of which 23 were detected at least once. PFOA had the highest detection frequency of these compounds at 52%, with an average concentration of 6.4ng/L. There was no significant correlation found between the concentrations of different compounds in a sample, nor was there a clear pattern in the spatial distribution of ultrashort PFAS throughout the state. This spatial ambiguity implies a lack of major point sources for ultrashort PFAS in Rhode Island, a trait that differs from their longer-chain counterparts and prompts deeper investigation into the sources of these compounds. Though there are currently no guidelines in the United States for TFA concentrations in drinking water, the elevated source water levels highlight the need for further research into the health effects of ultrashort-chain PFAS on both humans and biota.

4.25.P-Th195 Optimization of an Analytical Method for the Quantification of Trifluoroacetic Acid and Screening of Other PFAS Residues in Wine and Grape Juice

Zhi Hao Chi[1], Lan Liu[1] and Stéphane Bayen[1] (1)McGill University

Per- and polyfluoroalkyl substances (PFAS) are persistent environmental contaminants associated with potential adverse health effects following human exposure. Legacy long-chain PFAS, including perfluorooctanesulfonic acid and perfluorooctanoic acid, have been extensively investigated over the past decade; however, current toxicity data of short-chain PFAS regarding human exposure remain limited. Trifluoroacetic acid (TFA), an ultra-short-chain PFAS, has previously been reported in wine, but current data available on its human exposure through food and other beverages remain limited. The detection for TFA, as well as other short-chain PFAS using current analytical approaches remains challenging due to their high polarity and mobility, highlighting the need for improved sample preparation and analytical methods.

The objective of this study was to develop a suitable LC-MS analytical workflow for the determination of TFA

and various other short-chain PFAS in beverages such as wine and grape juice. After sample preparation, liquid chromatography quadruple time-of-flight mass spectrometry (Agilent Technologies) was used to detect presence of short chain PFAS residues in wine and grape juice samples using an Altura Poroshell PFAS column (Agilent Technologies, 2.7 µm x 2.1 mm x 100 mm). In addition, non-targeted screening was performed to investigate the presence of medium and long chain PFAS in these matrices. TFA was consistently detected, with initial concentrations ranging between 13.64 ng/mL to 233.72 ng/mL. These results suggest that beverages may represent a relevant dietary source of exposure to TFA and potentially other short-chain PFAS.

Overall, this study demonstrates the importance of improving analytical approaches for highly mobile short-chain PFAS in complex agri-food systems. The findings also support the need for broader monitoring of TFA and related compounds across a larger number of beverage samples, as well as potential water sources, such as rainwater and clean water used in agricultural and food-processing systems. Such monitoring is important to properly describe the transfer pathways of TFA and other PFAS residues into wine, grape juice, and other food-related matrices, thereby improving our understanding of human dietary exposure to these chemicals.

4.25.P-Th196 A Boring but Striking Survey of Trifluoroacetic Acid (TFA) in Fresh and Archived Surface Waters in Canada

Shane de Solla[1] and Patricia Gillis[1] (1)Environment and Climate Change Canada

There has been great interest in per- and polyfluoroalkyl substances (PFAS), which has been growing the last 15 years judging from the exponential increase in publications on their environmental fate and toxicity. Until recently, there has been less environmental interest in trifluoroacetic Acid (TFA), given that it is not a high-volume production chemical, and it is much less toxic than its longer chain cousins. Recent studies have indicated, however, that it is a favoured degradation product from CF3 containing precursors, such as chlorofluorocarbons, and selected pesticides and pharmaceuticals. To get a sense of TFA contamination in the Canadian environment, we conducted an opportunistic survey by analyzing water samples collected from three unrelated Environment and Climate Change Canada (ECCC) projects; i) crayfish and water sampling project to assess PFAS bioaccumulation from airport sources in Ontario, ii) samples collected as part of a Chemicals Management Plan project from the Grand River Watershed, Ontario, and iii) the proficiency testing and reference materials programs. The first two programs had surface water samples collected from targeted sites which were then frozen prior to analysis, whereas the last has archived water samples used as reference materials, which were at 4o C between 2 to 24 years prior for analysis for TFA. Five ultrashort PFAS, including TFA, were measured by SGS AXYS Method MLA-120, using isotope dilution LC-MS/MS methods. Levels of TFA ranged from below detection (< 5 ng/L), to a maximum of 3300 ng/L (mean = 1253.5 ng/L, 95% percentiles 94.4 to 2584.5). There was no relationship between age of the reference materials and concentrations of TFA (r2 = 0.008), no indication levels were affected by airports, and no apparent gradient across the Grand River watershed, despite the presence of multiple wastewater treatment plants. Drinking water samples (n = 3) from 2014 to 2025 also showed no pattern, but treatment of the drinking water (by reverse osmosis and Mill-Q) seemed to reduce levels below MDL. While obvious TFA was omnipresent in the Canadian aquatic environment, there appeared to be little variability in their concentrations.

Transboundary and Legacy Pollutants in Aquatic Systems

4.26.T-01 Investigating the Potential Impacts of Upper Columbia River Sediments to Early Life Stage Chinook Salmon (Oncorhynchus tshawytscha)

Melissa Driessnack[1] and Jenifer McIntyre[1] (1)Washington State University

The Upper Columbia River (UCR), which spans the United States–Canada border, contains legacy deposits of slag and metal-contaminated sediments associated with historical smelting activities. Slag deposits consist primarily of iron, silica, and lime but also contain elevated concentrations of metals including zinc, lead, copper, and cadmium. In addition, historical liquid effluent discharges from upstream smelting operations contributed metal contamination that subsequently sorbed to river sediments. Concentrations of several metals in UCR sediments and porewaters have been reported to exceed ambient water and sediment quality criteria, raising concerns regarding their potential ecological effects. These contaminated sediments can serve as ongoing sources of exposure for aquatic organisms, particularly during sensitive early life stages when prolonged contact with sediment and porewater may facilitate contaminant uptake and toxicity.

Efforts to reintroduce Chinook salmon (Oncorhynchus tshawytscha) upstream of Chief Joseph and Grand Coulee Dams have identified multiple candidate spawning habitats within the UCR. Salmon embryos and alevins develop in redds, which puts them in direct contact with slag-impacted sediments and interstitial porewaters during critical periods of development. To evaluate potential risks, eyed Chinook salmon embryos obtained from Entiat National Hatchery were reared through swim-up in direct contact with sediments collected from three candidate spawning locations (Deadman's Eddie, Steamboat Rock, and International Border Gage). Survival was monitored throughout development, and morphometric endpoints were assessed at multiple developmental stages to evaluate sublethal effects associated with sediment exposure. While survival exceeded 90% across all sites, potential changes in morphometrics, lipid content, and swimming performance were also evaluated.

This study provides a controlled assessment of early-life-stage exposure to legacy sediment-associated contaminants in the Upper Columbia River and contributes critical information regarding the toxicity and ecological implications of historical metal contamination in aquatic systems.

4.26.T-02 Determining Post-Industrial Deposition of Mercury, Arsenic and Lead Near a Non-Ferrous Smelter in Rouyn-Noranda, Quebec

Gabriel Philippe[1], Igor Lehnherr[1], Jane Kirk[2], Amber Gleason[2], Greg Lawson[2] and Elsa Dejoie[1] (1)University of Toronto, (2)Environment and Climate Change Canada (ECCC)

Important emitters of anthropogenic Mercury (Hg) in North America including coal burning, gold mining and non-ferrous metal smelting have been increasingly regulated since the 1970s. Despite this, recent studies show persistently elevated Hg deposition near historically dominant point sources. Environmental archives such as dated lake sediment cores can help quantify deposition of Hg and other contaminants over long time periods and substitute lacking long-term monitoring data near long-standing point sources. One example is the Horne copper smelter in Rouyn-Noranda, Quebec. Located in a remote boreal forest environment ~500 km Northwest of Montreal, the Horne is the dominant source of atmospheric metal deposition in the region. This study aims to reconstruct Hg accumulation sourced from the smelter since operations began in 1927 and provide an updated assessment of other priority pollutants, such as arsenic (As) and Lead (Pb), in the area. Sediment cores were

extracted from 8 lakes 5 to 75 km from the smelter. Cores were dated using Lead-210 radiometric dating and analysed for concentrations of Hg and 49 other elements to create a time series of deposition from the pre-smelter period to modern day. Hg concentration and accumulation was highest in near-field lake sediments (<10 km from the smelter), with fluxes showing an initial peak between 1970 and 1990 at ~2.5 to 4 times pre-impact levels (PILs). Following emission reductions and the closure of local mines in the 1970s, Hg deposition declined to ~2-3 times PILs, with resurgences to new peaks after 2010. Mid-field lakes (10-50 km from the smelter) showed variable trends, with some experiencing an initial Hg deposition peak of ~1.5 to 3.5 times PILs between 1950 and 1970, and occasionally a second peak between 1990 to present day. Far-field lakes (50-75 km from the smelter) did not exhibit pronounced peaks, but rather a general increase over time, consistent with continent-scale trends in Hg emissions. As and Pb concentrations show high peaks in lake Drolet (5 km) between 1980 and 2000 and steeply decline with distance. Reconstructing spatial and temporal trends of Hg enables the evaluation of the impacts of the changing Horne smelter's emissions on local lakes and the timeline of ecosystem response and recovery. This data will support the development of national emission policy to aid impacted communities and contribute to the effectiveness evaluation of the UNEP Minamata Convention on Mercury.

4.26.T-03 Dynamic Transport and Dispersion of Organic Pollutants in Different Compartments of the Rur River, Germany

Christina van der Marel[1], Karolina Nowak[2] and Jan Schwarzbauer[3] (1)Environmental Geochemistry, Institute for Integrated Natural Sciences, University of Koblenz; Institute for Organic Biogeochemistry in Geo-Systems, RWTH Aachen University, (2)Environmental Geochemistry, Institute for Integrated Natural Sciences, University of Koblenz, (3)Institute for Organic Biogeochemistry in Geo-Systems, RWTH Aachen University

Rivers and humans are closely connected: in terms of settlement, water use, wastewater discharge, energy production, transportation, etc. Accordingly, the human impact has nowadays drastically modified and altered the appearance of rivers. Besides structural changes, anthropogenic development has led to an increased pollution of river systems.
Especially organic pollutants are of great relevance for risk assessments, as they often have environmentally relevant properties such as a high persistence, toxicity or tendency to bioaccumulate. Therefore, to determine the spatial and temporal distribution patterns of organic pollutants, four regular (bi-annual) as well as flood-related sampling campaigns were carried out on the Rur river in western Germany. Samples of the aqueous (river water) and the sedimentary phase (riverbed, floodplains) were taken along the entire river course.
Non-target screenings using Gas Chromatography/Mass Spectrometry (GC/MS) revealed the presence of a wide range of organic pollutants. Most of them were xenobiotics, including pharmaceuticals, constituents of personal care products, or various industrial chemicals (e.g., flame retardants).
Emission profiles of these pollutants were tracked over the river course and effluents from wastewater treatment plants (WWTPs) were identified as a major source of emissions. There was a clear bipartition in the pollution of the river itself, reflecting the much stronger urban and industrial land use in the lower course of the catchment. Generally, the transport of organic pollutants in the aqueous and sedimentary phases was closely related and only disrupted by great anthropogenic impacts such as a dam system in the upper course. This dam system also had a substantial effect on the transport of sediment-bound pollutants during flood events. Instead of a pollutant accumulation on the floodplains, there was an enrichment in the riverbed itself. In contrast, the aqueous compartment showed mainly seasonal variations.

Overall, the regular and event-related sampling enabled a holistic assessment of the distribution and transport patterns of various organic pollutants. Major emission sources, pollutant diversity as well as potential areas for accumulation and remobilization were defined, providing an important basis for risk assessments and the evaluation of further research needs.

Disclaimer/Disclosure: C.M. was financially supported by the RWTH Aachen University Scholarships for Doctoral Students.

4.26.T-04 Toxicological Effects of Cotton and Polyester Microfibers on Mediterranean Mussels

Stephanie Wang[1], Kevin Landrini[2] and Oladimeji Ayo Iwalaye[3] (1)Ocean Wise Conservation Association, (2)Department of Earth, Ocean, and Atmospheric Sciences, University of British Columbia, (3)University of British Colombia, Ocean Wise Conservation Association

Microfibers are the dominant microplastic morphology found in marine environments, yet direct comparative studies between synthetic and natural fibers under environmentally relevant conditions remain limited. This thesis evaluates the chronic sub-lethal effects of cotton (natural) and polyester (polyethylene terephthalate, PET) microfibers, including chemically treated and untreated variants, on adult Mediterranean mussels (Mytilus galloprovincialis). Mussels were exposed for five weeks to 0, 100, 1,000, and 10,000 fibers L-1 under chronic laboratory exposure conditions, followed by a one-week depuration phase. Measured endpoints included oxidative stress biomarkers (catalase and superoxide dismutase), immune defense enzymes (acid phosphatase and alkaline phosphatase), acetylcholinesterase activity, and physiological metrics including clearance rate, respiration rate, body condition index. Microfiber ingestion, translocation, and retention were quantified across different tissue types.

Both fiber types induced identifiable biological responses, but magnitude and persistence differed. Cotton exposure elicited stronger and more consistent dose-dependent responses in oxidative stress and immune biomarkers, particularly in gill tissue, with 3–5-fold elevations in SOD relative to controls. Cotton fibers also showed increased retention and incomplete depuration from soft tissues, which was accompanied by sustained effects to AChE activity, suggesting long-term cholinergic disruptions. In contrast, polyester exposure produced more moderate and variable biomarker responses, with more efficient fiber depuration and partial physiological recovery after depuration. Chemical treatments on the textile fibers had minor and inconsistent effects relative to fiber type.

Overall, results show that natural fibers cannot be assumed to be inert. Fiber morphology and retention dynamics appear to be the major drivers of biological responses. By integrating multi-tissue biochemical markers with organism-level metrics under environmentally relevant microfiber concentrations, this thesis provides a mechanistic ecotoxicological framework for assessing textile microfibers in coastal ecosystems and challenges assumptions regarding the relative safety of natural versus synthetic materials.

4.26.T-05 Fish Eye Lenses As Archives of Environmental Change: Reconstructing Historical, Reservoir-Driven Mercury Bioaccumulation and Carbon Cycling

Annabelle Vogl[1], Dominic Ponton[2], Roxanne Razavi[3], Karin Limburg[3], Hadis Miraly[4], François Bilodeau[5] and Marc Amyot[1] (1)University of Montreal (UdeM), (2)Université de Montréal (UdeM), (3)SUNY ESF,

(4)Southern Illinois University-Carbondale, (5)Hydro-Québec Environnement

Reservoir impoundments alter riverine carbon (C) cycling as submerged terrestrial C is decomposed and greenhouse gases are produced. The resulting increase in microbial activity and oxygen depletion can enhance microbial mercury (Hg) methylation. Methylmercury (MeHg) is a neurotoxin that bioaccumulates in aquatic organisms and biomagnifies along food webs, exposing fish and human consumers. Reservoir characteristics (i.e., water residence time and land flooded area) regulate C and Hg dynamics, but their long-term temporal influence remains uncertain and requires extensive sampling effort. Fish eye lenses have recently emerged as a powerful tool to address this as they grow incrementally and preserve fine-scale lifetime records of Hg bioaccumulation and C cycling within a single individual. Lenses from four hydroelectric reservoirs (Romaine River, Québec, Canada) and an upstream control fluvial lake were analyzed to reconstruct histories of Hg bioaccumulation, C cycling (C isotopic signature; $\delta^{13}C$), and trophic position (nitrogen isotopic signature; $\delta^{15}N$) in Northern Pike (Esox lucius), Lake Whitefish (Coregonus clupeaformis), and White Suckers (Catostomus commersonii). While C isotopic signature remained stable over time in the control lake, it was lower and temporally variable in and among reservoirs, indicating that changes in C cycling were associated with impoundment and varied with reservoir characteristics. Mercury was negatively associated with $\delta^{13}C$, suggesting that increased C decomposition (lower $\delta^{13}C$) enhances Hg bioavailability by supporting MeHg production. Consistent with this, in Lake Whitefish lenses, higher Hg bioaccumulation rates (change in log10Hg over time) occurred in reservoirs with larger land flooded areas and longer water residence times. Amid expanding hydroelectric reservoir development globally, these findings further the understanding of the impact of reservoir characteristics on temporal C and Hg dynamics. This informs both the planning of future hydroelectric development and the assessment of its impacts on ecological and human health.

Disclaimer/Disclosure: This work was supported by a grant from the Fonds de recherche du Québec to A.V. [grant number 2001329], a Natural Sciences and Engineering Research Council of Canada (NSERC, in partnership with Hydro-Quebec and the Innu Council of Ekuanitshit) Alliance grant [grant number ALLRP 560330-20] to M.A.

4.26.T-06 Nanoplastics Toxicity to Zebrafish Larvae: Evaluating the Effects of Reference Material

Ludovic Hermabessiere[1], Michael G Morash[2], Anja Vogt[2] and Lee D Ellis[3] (1)National Research Council (NRC) Canada, (2)National Research Council Canada, (3)National research Council Canada

Micro and nanoplastics are found world-wide in all environments. Once in the environment, these synthetic particles are often ingested by organisms which can lead to adverse biological effects. In order to understand how micro and nanoplastics cause biological effects, laboratory experiments typically use spherical particles as micro or nanoplastics model. However, these spherical particles are not representative of the micro or nanoplastics found in the environment. Therefore, there is a gap, especially for nanoplastics, to evaluate their toxicity using environmentally relevant particles. In order to close that gap, a nanoplastic reference material was recently created with characteristics that more closely resemble nanoplastics found in the nature.
In this work, we tested the hypothesis that these relevant nanoplastics would be more toxic to aquatic organisms than spherical particles using our larval zebrafish model.
The NRC Zebrafish Embryo Toxicity (ZET) test was used to compare the toxicity of two spherical polystyrene

nanoplastics (commonly use in nanoplastic toxicity studies), one spherical-like polypropylene nanoplastic and one flake-like reference material polypropylene nanoplastic. Following exposure, morphological abnormalities were recorded, behavior analyses were performed and Effective Concentration 20% (EC20) were calculated to compare toxicity.
All nanoplastics tested affected the larvae zebrafish with different effects noted. Only the spherical-like polypropylene caused 100% lethality at the higher concentration tested (100 and 200 mg/L) while other nanoplastics showed only morphological abnormalities at the highest concentration. Specifically, the flake-like reference material made of polypropylene was the most toxic on the larvae with an EC20 of 1.7 (± 1.1 standard deviation) mg/L followed by the spherical-like polypropylene with an EC20 of 2 (± 4) mg/L followed by the two spherical polystyrenes with EC20 of 51 (± 11) and 54 (±10) mg/L. Behavior analysis revealed no differences in distance travelled for all nanoplastics used.
This work demonstrates that non-regular shaped nanoplastics are more toxic than spherical ones, which are more commonly used in conventional nanoplastic toxicity assays. As a consequence, much of the current toxicity data on nanoplastics, may underestimate the risk posed by these particles to aquatic organisms.

Transboundary and Legacy Pollutants in Aquatic Systems

4.26.P-Th281 Quantifying Mercury Dynamics in Aquatic Invertebrate Food Webs Across a Land-to-Sea Gradient

Gretchen McPhail[1], Mark Mallory[1] and Nelson O'Driscoll[1] (1)Acadia University

Estuarine river systems transport mercury between land and sea, and changing biogeochemical processes influence its retention, speciation, and biological uptake along that continuum. Methylmercury (MeHg) is of principal concern due to its high bioaccumulation and biomagnification potential; however, changes in the trophic transfer of MeHg across environmental gradients are poorly quantified. To determine if the rate of MeHg biomagnification in aquatic invertebrate communities shifts between the Jijuktu'kwejk River and its outflow into the Bay of Fundy, Canada, we analyzed functional feeding groups (FFGs), carbon and nitrogen stable isotope ratios, and MeHg concentrations of 56 invertebrate taxa organized into freshwater, brackish, and coastal habitats. The MeHg concentrations of freshwater invertebrates increased from primary consumers to predators, where piercing and engulfing predator functional groups (mean MeHg 226.8 ± 136.0 and 105.8 ± 51.5 ng/g dry weight (dw), respectively) frequently exceeded the Canadian guideline for the protection of wildlife consumers (137.6 ng/g dw). There was no trend in MeHg bioaccumulation among FFGs for brackish and coastal ecosystems, and the mean MeHg concentrations of these ecosystems (19.1 ± 23.3 and 15.7 ± 12.1 ng/g dw, respectively) were ~10 times below the guidelines (202.5 ng/g and 161.9 ng/g dw, respectively). As such, only the freshwater invertebrate community showed significant MeHg biomagnification (Trophic Magnification Slope (TMS) > 1, $p = 0.0096$). The shifting efficiency of MeHg transfer across invertebrate communities along the land-to-sea system may be explained by differences in food web organization and structure, while changing water chemistry may influence the bioavailability and initial uptake of mercury species at the base of the food web. These data highlight an increased risk for the trophic transfer of MeHg in freshwater wildlife relative to marine-influenced regions and furthers our knowledge of MeHg food web dynamics across highly interconnected but functionally distinct ecosystem networks.

4.26.P-Th283 Bioaccumulation of Hg and As in Freshwater Invertebrates From Ponhook Lake, Nova Scotia: Effects of Historical Gold Mine Tailings

Benjamin Gooley[1], Ian Spooner[1], Nick Hill[2] and Nelson O'Driscoll[1] (1)Acadia University, (2)Southwest Biosphere Reserve Association

Historic artisanal and small-scale gold mining (ASGM) in Nova Scotia has left a legacy of mercury (Hg) and arsenic (As) contamination in lacustrine ecosystems across the province. These contaminants may pose a risk to aquatic organisms due to their ability to bioaccumulate and cause toxic effects. The Malaga Gold District, situated between Ponhook and Molega lakes, is a historic ASGM site. Our research aimed to quantify the contamination of Hg and As in the shoreline sediments and invertebrate communities of Ponhook Lake. In the summer of 2025, we collected sediment samples from transects along the northern and southern shores of the lake. These sediments were dried and sorted to a consistent silt-clay texture through a 200 µm stainless steel sieve. The sorted sediments were analyzed for total mercury (THg) and total arsenic (TAs) using a NIC MA-3000 direct mercury analyzer and Epsilon 1 X-Ray Fluorescence for As. Preliminary analyses has shown that there are elevated concentrations of Hg (178 - 5788 ng g-1; n = 16) and As (106 - 1060 µg g-1; n = 10) in localized sediments near the mine tailings. We also summarize new data collected for THg, methylmercury, and TAs in aquatic invertebrates collected in the summer of 2026. The results of our research may inform future remediation efforts and policy decision making at Ponhook and other legacy gold mines in Nova Scotia.

Disclaimer/Disclosure: Southwest Biosphere Reserve Association, MITACS Accelerate, NSERC

4.26.P-Th284 Assessing Transboundary Movement of Organic Chemicals in Water Using a Novel Composite Integrative Passive Sampler

Damian Shea[1], Wenling Wang[2], Prahlad Jat[3], Xiang Kong[1], Xin-Rui Xia[1] and Goran Bozinovic[4] (1)Statera, (2)Yunnan University, (3)University of North Georgia, (4)University of California San Diego (UC San Diego)

Transboundary waters account for 60% of the world's freshwater supply, with 153 countries sharing 286 transboundary rivers and lake basins. Actions (or inaction) by upstream countries can have significant negative consequences to the public health and ecosystems of downstream countries, with potential to create serious conflict. Despite the importance of transboundary waters, very few have had adequate characterization of the movement of potentially harmful chemicals. We present two examples where the use of a novel passive sampling device, the Composite Integrative Passive Sampler (CIPS), provided a higher quality data set for assessing cross-border movement of chemicals than sampling water or sediment. CIPS were deployed in the Tijuana River at the US-Mexico border and the Red River that flows from China to Vietnam. In both cases, the CIPS yielded a larger number of detected chemicals compared to sediment and water, and nearly the aggregate of all chemicals detected in water plus the sediment. CIPS is a mixed-phase passive sampling device that accumulates both polar and non-polar chemicals from water. That property, along with the in-situ preconcentration that takes place with all passive samplers, allowed for the detection of both highly hydrophobic chemicals (e.g., DDT, PCBs, PAHs, pyrethroids, phthalates) and highly water-soluble chemicals (e.g., atrazine and chlorothalonil metabolites, haloacetic acid disinfection byproducts). With regard to the Tijuana River, there is a clear indication of a very significant source of all classes of chemicals coming across the border, with phthalates and haloacetic acids likely only coming from Tijuana, while other classes of chemicals having a significant input from Mexico superimposed on other smaller sources in the area. There is

much less input of chemicals from China to Vietnam in the Red River, with the dominant class being current use pesticides. These data are being used to design larger monitoring programs that will inform policy makers and help to prioritize transboundary chemical hazards in these watersheds.

Urban Infrastructure as a Vector for Emerging Contaminant Exposure

4.27.T-01 Persistent Neuroactive Contaminants as an Emerging Framework for Lifespan Neurological Risk

Adam Gushgari[1] (1)Eurofins Environment Testing

The recognition of endocrine disrupting compounds (EDCs) as a distinct contaminant class fundamentally reshaped environmental health science, not because new chemicals were discovered, but because a unifying mechanistic framework connected disparate evidence into a coherent public health concern. That framework drove regulatory action, research investment, and ultimately, protection of human health. We propose that environmental science is at an analogous inflection point with respect to neuroactive contaminants.
This presentation introduces Persistent Neuroactive Contaminants (PNACs) as a proposed novel environmental contaminant classification defined by two core criteria: environmental persistence and the capacity to inappropriately modulate neural plasticity at environmentally relevant concentrations, individually or through mixture effects. Unlike existing neurotoxicant frameworks organized around acute toxicity or developmental critical windows, PNACs are distinguished by their potential to disrupt neuroplasticity regulation across the entire lifespan. Neural plasticity is not exclusively a developmental phenomenon; it is a regulated biological process governing learning, memory consolidation, stress response, and cognitive resilience into adulthood. Inappropriate modulation at any life stage carries meaningful public health consequences.
Candidate compound classes include fluorinated pharmaceuticals, organophosphate pesticides, bisphenols, polybrominated flame retardants, and plasticizer-associated compounds, several detected ubiquitously in human tissue and environmental matrices. The PNAC framework explicitly incorporates mixture effects as a classification consideration, recognizing that compounds below individual effect thresholds may collectively produce neuroplasticity disruption that single-compound regulatory frameworks would not detect.
This talk outlines the proposed classification criteria, surveys the mechanistic literature supporting candidate compound identification, and makes the case that the observed global burden of neurological and psychiatric disease warrants a coordinated scientific and regulatory response built on a rigorous, evidence-driven classification framework.

4.27.T-02 Monitoring Microplastics in King Tide Floodwaters in Norfolk, Virginia, USA

Meredith Seeley[1], Catherine Wardinski[1], Liam Green[1], Margaret Mulholland[2] and Tejaswini Ronur Praful[2] (1)Virginia Institute of Marine Science, (2)Old Dominion University

King tides are perigean spring tides which can cause flooding in low lying coastal regions. Tidal flooding is increasingly common in the Hampton Roads region of Southeastern Virginia where a combination of land subsidence and sea level rise now cause regular sunny day flooding. The Elizabeth River and Lafayette Rivers, tributaries of lower Chesapeake Bay, are two tidal rivers that commonly flood adjacent land at high tide. The floodwaters collect variety of contaminants and pollutants from the adjacent landscape during flooding and

transfers to the rivers when tide recedes. Nutrient and fecal contamination of floodwaters have been observed, however, the transport of microplastics (MPs) in floodwaters has not been examined. To evaluate the accumulation and transport of MP to tidal rivers during tidal flooding, floodwater samples were collected at five sites in Norfolk, Virginia. Floodwater samples were collected three days and one day prior to, as well as the day of, the King tide flooding event in October 2025. At each site, 4 L of water was collected in glass jars alongside 1 L field sampling blanks. Water samples underwent lab processing including filtration and organic matter digestion with hydrogen peroxide. The water samples were analyzed for various polymer types using pyrolysis - gas chromatography / mass spectrometry (Py-GC/MS). Target analytes included polymers commonly used in plastic goods (polyethylene, polypropylene, polystyrene, polycarbonate, polyethylene terephthalate, poly(methyl methacrylate) and nylon) as well as tire wear rubber particles (TWP). Preliminary results indicate that all samples had some plastic or TWP present. TWPs had the highest concentrations in all of the floodwater samples. The most commonly detected plastic polymer was polypropylene. The King tide flood event samples had significantly higher concentrations of both, as compared to water samples collected from the tidal rivers prior to the King tide flooding. Preliminary results indicate that the floodwaters contained high concentrations of MPs and floodwaters acted as a source of MPs to local waterways. This dataset contributes towards our emerging understanding of sources of MPs to a major, urbanized river system of the lower Chesapeake Bay. Understanding these non-point contributions of particulate contaminants into environment is critical to improve the design and management of stormwater drainage, as well as understand the impact of sea level rise on water quality.

4.27.T-03 Exploring the Leaching and Transformation Potential of PFAS in AFFF Encapsulated Concrete

Logan Miller[1], Michael Deible[2], Shih-Hung Yang[3] and Michael Baker[3] (1)Shimadzu, (2)RJ Lee Group, (3)RJ Lee Group, Inc.

Concrete exposure to AFFF is a well-established problem. Airports and other facilities where AFFF have been used can act as a point source for release of PFAS to the environment. Encapsulation of hazardous materials in concrete has long been considered as an easy and low-cost solution. Leaching of AFFF from exposed concrete would indicate that encapsulation is not viable for AFFF contaminated water. Here we explore the leachability of AFFF from various types of concrete as well as concrete enhanced with known PFAS adsorbents to demonstrate a decrease in PFAS leaching potential from the concrete.

Various concrete mixes were used to cast concrete cores for the testing. Different adsorbents were incorporated into the concrete to help assess the impact on PFAS leaching with each type of material. Once the cores were cured, they were prepared for analysis by undergoing procedures that are detailed within LEAF 1315 and ASTM 8535 extraction procedures. Once the concrete was extracted aliquots of the solution were injected into a high-resolution mass spectrometer to compare the PFAS profiles before and after casting to determine the degree of leaching, as well as determining the transformation by-products that occurred during the curing period. The samples were processed using FluoroMatch as well as the mass spectrometry vendor's native non-targeted analysis software to screen/detect/search for any possible compounds that contained fluorine moieties. Preliminary data has shown that both PFOS and 6:2 FTS based AFFF (Generation I and Generation II) leaches readily from concrete that has been cast with AFFF contaminated water. Investigations into various types of concrete formulations show no impact on leachability. However, concrete enhanced with readily available PFAS adsorbents can reduce the leaching potential of AFFF from concrete as much as 95%. Granulated

activated carbon, Organoclay, and ion-exchange resin mixed into the concrete at one weight percent before casting with AFFF contaminated water shows reduced leaching potential. High-resolution mass spectrometry characterization of AFFF before and after encapsulation revealed analytes beyond the standard EPA or ASTM targeted analytical compound lists and aided in the elucidation of the transformation products that occurred in an alkaline environment, such as concrete.

4.27.T-04 Riverine PFAS Dynamics Reveal Wastewater and Urban Infrastructure As Dominant Sources of Contamination in a Mixed-Use Watershed

Joseph Charbonnet[1], Abdullahi Adeola[1], David Green[1] and William Crumpton[1] (1)Iowa State University

Both urban and agricultural activities within watersheds have been implicated as sources of per- and polyfluoroalkyl substances (PFAS) to downstream ecosystems and drinking water resources. To evaluate the role of urban infrastructure in PFAS mobilization, we conducted weekly monitoring of 40 targeted PFAS at four locations along the South Skunk River–Ioway Creek system in central Iowa from April through November 2023. Sampling locations within this mixed-use watershed were selected to distinguish contributions from agricultural land use, urban runoff, and municipal wastewater treatment infrastructure. Median total target PFAS concentrations increased from 5 ng/L at upstream agricultural sites to 28 ng/L downstream of the Ames wastewater treatment plant (WWTP), while area-normalized PFAS yields increased more than five-fold across the urbanized reach. Spatial patterns, load calculations, hydrologic analyses, and PFAS fingerprints implicated the municipal WWTP as the dominant PFAS source within the watershed. Although WWTP effluent represented a median of only 8.7% of streamflow, downstream PFAS loads were approximately three times greater than those observed immediately upstream; they were eight times higher than in agriculture-dominated stretches. Concentrations generally declined with increasing discharge, indicating dilution impacts, yet PFAS loads increased sublinearly with flow at all sites. Summer and fall storm events produced pronounced PFAS concentration spikes downstream of urban areas, highlighting the importance of stormwater infrastructure and runoff pathways in episodic contaminant transport. Fourteen PFAS were detected during the study, with PFBS, PFHxA, PFOA, and 6:2 FTS occurring most frequently. Short-chain PFAS dominated the contaminant profile, accounting for 80–95% of total measured PFAS mass. These findings demonstrate how urban infrastructure and activities can substantially influence PFAS occurrence, transport, and human exposure potential in receiving waters. The results further illustrate the importance of combining concentration, load, and yield analyses to distinguish infrastructure-derived contaminant sources from diffuse watershed inputs. As communities seek to reduce PFAS exposure and protect drinking water resources, targeted monitoring and management of urban water infrastructure will be essential components of effective mitigation strategies.

4.27.T-05 Investigating Bioavailable Chemical Trends in the Columbia River Over One Year

Kalealani Gurfield[1], Kim Anderson[1] and Lane Tidwell[1] (1)Oregon State University

The Columbia River Basin is the fourth largest watershed in North America, serving over 8 million people and 13 diverse ecosystems. It has recently become a focal point for research, given its history and proximity to heavy industrial activity. To assess the health of the river, this study utilized passive sampling devices (PSDs). For a continuous 365 days, low density polyethylene (LDPE) passive sampling devices were deployed for 30-

day intervals at 10 sites along the lower 200 miles of the Columbia River. Of special interest was the influence of built systems – man-made infrastructure with landscape level effects – on chemical profiles; PSDs were deployed immediately above and below two dam systems and a highly industrialized/urbanized Superfund area located at the confluence of the Columbia and Willamette Rivers. This study aims to characterize and quantify a suite of ~1500 contaminants (PAHs, PCBs, flame retardants, dibenzofurans, pesticides, personal care products, and pharmaceuticals) using GC-MS targeted and suspect methods.
This research is part of an ongoing project where field sampling will culminate in the summer of 2026. As such, these conclusions are preliminary and may not be representative of the entire dataset. Results suggest that the Dalles Dam acts as a sink for PAHs; concentrations of PAHs below the dam were consistently lower than their upriver counterparts (52% of chemical shifts were statistically significant ($p\text{-value} \leq 0.05$)). Additionally, more PAHs were detected upriver than downriver of the dam. At the Columbia/Willamette confluence, it is likely that the Willamette River is contributing to chemical inputs in the Columbia River; concentrations below the confluence were consistently higher, with 69% of chemical shifts being statistically significant. Similarly, more PAHs were detected downriver than upriver across months. Data from the Bonneville Dam is inconclusive; no trend has been identified that suggests influences from dam operations on chemical profiles. This is the first study to investigate the effects of dams on chemical profiles, therefore providing insight into the impacts of engineered systems on chemical activity. By identifying trends and sites with high levels of contaminants, the data may be used to inform ongoing cleanup, restoration, and preservations efforts in the river.

4.27.T-06 Surveying Urban Stormwater Quality Using Cell-Based Bioanalytical Tools

Mackenzie Rosebrugh[1], Eric Camm[2], Norman Neumann[3], Maricor Arlos[1] and Norma Ruecker[2] (1)University of Waterloo, (2)City of Calgary, (3)University of Alberta

Urban stormwater is a significant source of micropollutants that can adversely affect aquatic organisms and compromise source water quality. These substances include complex mixtures of pesticides, polycyclic aromatic hydrocarbons (PAHs), industrial chemicals, and other micropollutants that often occur at trace concentrations yet may still elicit biological responses through additive, synergistic, or cumulative effects. In Calgary, Alberta, stormwater from several outfalls discharge into the Glenmore Reservoir, a critical source water supply for the city. This study evaluates the cell-based toxicity of stormwater entering a source water reservoir by analyzing the baseflow and rain event discharges from 4 outfalls and comparing results with 3 surface water sites (1 upstream and 2 in the reservoir). Given that urban stormwater is difficult to characterize, this study also integrates chemical analyses (PAHs, pesticides, other micropollutants) and microbial source tracking data with the cell-based bioassay results to identify potential sources of toxicity and improve understanding of the biological pathways affected by stormwater contaminants. Three bioassays were used to evaluate the toxicity including Yeast Estrogen Screening to evaluate endocrine disrupting activity, UMU-Chromo to assess mutagenicity, and A. fischeri assay to measure cytotoxicity. Preliminary results indicate that toxicity is often elevated during rainfall events, whereas elevated HF183 (human sewage marker) during baseflow may suggest sewage-related inputs. Together, these findings indicate that different contaminant sources may drive water quality impacts under wet- and dry-weather conditions and warrant further investigation into their relative contribution to observed biological responses. Ongoing work is examining how these patterns relate to observed toxicity responses. Overall, the results of this study will improve understanding of stormwater borne risks to source water quality. The results will also support the City of Calgary in prioritizing outfalls, targeting mitigation, and informing stormwater management strategies.

Urban Infrastructure as a Vector for Emerging Contaminant Exposure

4.27.P-We300 Seasonal Drivers and Land Use Patterns of Microplastic Abundance in Urban Stormwater Infrastructure and Flood Control Canals in South Florida

Marcellinus Ogudo[1], Ali Ebrahimian[2], Leonard Scinto[3] and Piero Gardinali[1] (1)Department of Chemistry and Biochemistry, Institute of Environment, Florida International University, (2)Department of Civil and Environmental Engineering, Florida International University, (3)Department of Earth and Environment, Institute of Environment, Florida International University

Microplastics (MPs) pollution is pervasive and attracting global attention due to the rapid increase in global plastic production. Traditional stormwater and flood control infrastructure systems, including storm sewers and canals, can act as critical pathways for the transport of MPs from urban areas to downstream water bodies. Currently, there is limited data on the abundance and characteristics of MPs in urban stormwater infrastructure systems globally, and no data in South Florida. This study investigates the occurrence and spatiotemporal distribution of MPs within urban storm sewers and flood control canals in South Florida. We hypothesize that urban stormwater infrastructure serves as an accumulation zone for MPs, and their abundance is influenced by spatiotemporal variables (e.g., land use/land cover and precipitation). Over one-year, monthly samples were taken at 18 storm catch basins across six prioritized land-use areas in Miami-Dade County, Florida, plus 15 sites along three flood-control canals. Land uses include High-Density Residential (HDR), Medium-Density Residential (MDR), Commercial (COM), Institutional (INS), Industrial (IND), and Green Open Space (GSP). Flood control canals include Biscayne Bay's major tributaries, Miami River (C-6), Little River (C-7) and Biscayne Canal (C-8). Samples were processed using widely recognized techniques for MPs, including filtration, digestion, and density separation. Particle counting and characterization were conducted utilizing brightfield microscopy and combined μFTIR/Raman spectroscopy, respectively. Rainfall and land cover data were taken from South Florida Water Management District and Miami-Dade County databases. Preliminary results show the widespread presence of MPs with abundance ranging from 2.0 to 506.0 particles/L in catch basins and 4.4 to 810.0 particles/L in canals. Additionally, the highest and lowest MPs abundance from catch basins were found in COM (120.6 ± 114.8 particles/L) and GSP (50.6 ± 63.1 particles/L), respectively, which were higher than those in canal sites, i.e., the highest MPs abundance in C-8 (68.1 ± 118.8 particles/L) and lowest in C-7 (45.2 ± 43.1 particles/L). This contrast suggests that catch basins act as accumulation zones that trap and concentrate MPs near their source, whereas canals dilute these inputs as they convey them downstream. The outcomes of this research provide insights about the sources and factors driving MPs transport within urban stormwater systems.

4.27.P-We301 Detection of Micropollutants in Stormwater Outfalls Using LC-MS/MS and SPE Extraction Techniques

Daniela Pulgarin-Zapata[1], Diba Ghahremani[1] and Maricor Arlos[1] (1)University of Alberta

Stormwater runoff can transport a wide range of micropollutants into receiving aquatic environments, and their occurrence and distribution may vary between baseflow and rain events. As many municipalities are now starting to invest in infrastructure to improve the quality of their point sources (e.g., wastewater treatment), understanding the relative contribution of stormwater runoff to overall water quality is becoming increasingly important, particularly in the context of ongoing urban growth and intensification. Monitoring micropollutants

in stormwater can also provide valuable insights into sources of anthropogenic contamination within urban watershed, including sewer leaks and storm-sewer cross connections. This study investigates the occurrence of micropollutants in stormwater samples collected during base flow and rain events. To support this work, we first developed a liquid chromatography tandem mass spectrometry (LC-MS/MS) method for the analysis of 20 target compounds, including 12 indicator compounds recently identified under European Union's Urban Wastewater Directive 2024/3019 for monitoring and assessment of wastewater-derived micropollutants. We also optimized a solid-phase extraction (SPE) procedure to improve analyte recovery and compound identification across complex stormwater matrices. Preliminary results demonstrated the presence of several target compounds in stormwater samples, including commonly detected municipal wastewater compounds such as venlafaxine, caffeine, carbamazepine, escitalopram, hydrochlorothiazide, irbesartan and citalopram. Additional optimization is still required for the extraction and/or analysis of highly polar compounds such as sucralose and metformin. Nonetheless, the results indicate that wastewater-derived substances make their way into the stormwater and their exact mechanism of transport warrants further investigation. Work is currently underway to compare the result of a 2026 field sampling campaign with other measured micropollutants (pesticides, polycyclic aromatic hydrocarbons) to evaluate co-occurrence patterns, source signatures, and spatial-temporal trends within the watershed. Overall, this work demonstrates that stormwater systems can serve as important pathways for wastewater-derived micropollutants and highlights the need to consider stormwater alongside traditional point sources when assessing and managing micropollutants in the watershed.

General: Engineering, Remediation and Restoration

6.03.P-Tu020 Selective Recovery of Cobalt and Nickel From Spent Lithium-Ion Batteries by Integrated Roasting and Chelation-Assisted Deep Eutectic Solvent Leaching

Eon-Seok Sim[1] and Seok-Young Oh[1] (1)University of Ulsan

The growing adoption of electric vehicles is expected to result in a significant increase in the volume of spent lithium-ion batteries (LIBs), highlighting the need for efficient and environmentally sustainable recycling methods. This study presents an optimized process for recovering critical metals—cobalt, nickel, manganese, and lithium—from spent LIBs. The method involves roasting followed by leaching using a deep eutectic solvent (DES) composed of propionic acid (PA), choline chloride (ChCl), and nitrilotriacetic acid (NTA), a chelating agent. Key operational parameters—including roasting temperature and duration, ChCl–PA molar ratio, leaching temperature and time, solid-to-liquid ratio, and NTA concentration—were systematically investigated. Roasting at 200 °C for 2 h improved leaching efficiencies of nickel and cobalt by 20.2% and 6.3%, respectively. Optimal leaching conditions were identified as 80 °C for 120 min with a solid-to-liquid ratio of 15 g/L. The addition of 0.07 M NTA shortened the leaching time from 120 to 60 min while achieving leaching efficiencies of 98.5% for lithium and 100% for cobalt, nickel, and manganese. Manganese was selectively separated from the leachate using D2EHPA, while cobalt, nickel, and lithium were subsequently recovered from the manganese-free solution using Cyphos IL 104 and oxalic acid. Leaching efficiency declined by 10–15% with each reuse of the DES. Overall, this approach offers a highly efficient and economically feasible strategy for metal recovery from spent LIBs, contributing to circular economy practices and sustainable battery waste management.

6.03.P-Tu022 In Situ Remediation of Pb Contaminated Urban Soils With Permanganate: Human and Environmental Health Implications

Mason Reid[1] and Nicholas Basta[1] (1)Ohio State University

Legacy lead contamination is a widespread problem that threatens human and environmental health in many urban areas around the world. Common approaches towards remediating highly contaminated soils often involve costly and highly destructive removal of soil rather than treating contaminated soil in situ. In situ remediation can be performed by applying substances capable of stabilizing the Pb, reducing the bioavailability and therefore toxicity of the metal to humans and other organisms. When four contaminated urban soils were treated with potassium permanganate (a reagent widely used in municipal water treatment processes), the in vitro bioaccessiblilty of the soil Pb was reduced drastically. At the high reagent application rate, the Pb bioaccessbility was reduced by 71-98.9% across the four soils; in all cases, the post-treatment Pb bioacessibility was below 10%. At the low reagent application rate, the Pb bioaccessiblity was reduced by 11.2-67.4%. Reductions of Pb bioaccessiblity to this degree imply strong potential to drastically reduce the toxicity of Pb faced by those individuals (and communities) exposed to these highly contaminated soils. X-ray absorption spectroscopy analysis further supports the long-term stability of the Pb complexes formed by the treatment.

Alongside these results, implementation techniques aiming to optimize both environmental and human health outcomes will be presented.

6.03.P-Tu023 Setting the (TRaP): Thin Reactive Amendment and Protective Capping for Arsenic and Mercury in Wetlands

Ellen Chapman[1], Heidi Gavel[1], David Lewis[1], Lauren MacDonald[1], Enobong Udoh[1], Kaitlyn Kerr[1], Bradley Knockwood[1], Logan Phillips[1], Samuel Sequeira[1], Liam Hill[1] and Linda Campbell[1] (1)Saint Mary's University

Legacy gold mine sites continue to present severe environmental challenges associated with arsenic (As) and mercury (Hg) contaminated tailings. Wetland sediments at these sites act as long-term contaminant sources due to porewater diffusion, redox-driven remobilization, and physical disturbance, and have been shown to be toxic to aquatic invertebrates while causing bioaccumulation in tolerant invertebrates and amphibians. Conventional remediation approaches such as dredging or thick capping can disrupt wetland structure and function, highlighting the need for cost-effective, minimally invasive alternatives. We developed a Thin Reactive Amendment and Protective Capping (TRaP) system designed to reduce the mobility, toxicity, and bioavailability of As and Hg in contaminated wetland sediments while minimizing physical disturbance in the wetland. TRaP consists of a two-layer design: a reactive amendment layer (microscale zero-valent iron) and a thin protective cap (silica sand, zeolite, bentonite, and a minor fraction of ZVI). From 2020–2023, TRaP was evaluated through a staged laboratory program including material characterization, batch adsorption experiments, benchtop ecotoxicity/bioaccumulation testing, and sediment column studies under varying redox conditions. Each stage progressively increased environmental realism and informed amendment optimization. Laboratory studies demonstrated reduced contaminant mobility and toxicity and supported advancement to field-scale testing. In summer 2023, a 15-month interdisciplinary field mesocosm experiment was initiated in a legacy gold mine–impacted wetland. Replicated mesocosms were used to evaluate TRaP under in situ conditions. Integrated assessments included contaminant concentrations and speciation in porewater, surface water, sediment, and biota, as well as plant health, invertebrate toxicity, microbial community responses, and

cap erosion resistance. Across laboratory and field scales, TRaP consistently reduced As and Hg exposure and demonstrated improved biological conditions relative to untreated sediments. Results support TRaP as a promising low-disturbance remediation approach for contaminated wetlands. Ongoing work is focused on refining material formulations and incorporating waste-derived and circular-economy amendments (e.g., cast iron waste and biochar) to improve sustainability, reduce cost, and expand applicability while maintaining performance.

6.03.P-Tu024 Wild Rice (Manoomin, Zizania palustris) Restoration in a Cattail (Typha spp.) Dominated Wetland Using Cut-To-Drown Management

Madeline Stanley[1], Alexandra Giuliano[2], Krista Robertson[1], Morgan Anderson[1], Vince Palace[1], Jyles Copenace[3] and Lisa Peters[1] (1)IISD Experimental Lakes Area (IISD-ELA), (2)University of Manitoba, (3)Makate Waagamichiwanang Gakinaa'amaatiwin Youth and Family Wellness Camp

Wild rice (Zizania spp.), is a traditionally important food to Indigenous peoples known as Manoomin. Historically, wild rice stands have declined due to anthropogenic and climate stressors, and are often outcompeted by dominant or invasive plants, like cattail (Typha spp.). Cattail are known for their well-established monocultures and ability to withstand harsh conditions, with potential to negatively impact wetland diversity and habitat. Specifically, the hybrid (Typha x glauca) is able to withstand variable water depths and nutrient conditions, making it an excellent competitor. In order to restore wild rice, cattail and other invasive plants may need effective management or control. The Makate Waagamichiwanang Gakinaa'amaatiwin Youth and Family Wellness Camp, in Treaty 3, northwestern Ontario, Canada, in collaboration with the IISD Experimental Lakes Area, are reintroducing Northern wild rice (Zizania palustris) in a cattail dominated wetland using cut-to-drown management, where cattails are cut below the water surface in the fall to deplete nutrient stores and oxygen supply to the rhizomes. In addition to restoring Indigenous food sovereignty, the study aims to assess ecosystem response to restoration efforts, and supports graduate student research on the use of environmental DNA techniques to monitor benthic invertebrate community response. From June to September 2025, six study plots (3 x 5 m) were monitored for water quality and chemistry, sediment chemistry, and vegetation biodiversity. In September 2025, three plots received cattail management, removing 23.75 to 32.20 kg of dry plant biomass. In October 2025, wild rice re-seeding in these sites was conducted in an Indigenous-led ceremony. In 2026, we will continue to monitor water, sediment, and vegetation in the managed and unmanaged sites to assess ecosystem response to restoration efforts. This collaborative study was established to address questions identified by Indigenous communities and we will discuss management and restoration results.

6.03.P-Tu025 Capturing Forever Chemicals (PFAS) From Leachates Using Fast-Growing Willows

Frederic Pitre[1], Eugenie Lemieux[2], Roberta D'Camp[3], Louis-Clément Barbeau[2], Justine Fontaine[4] and Sebastien Sauve[4] (1)University of Montreal (UdeM), (2)Ramo Inc., (3)IRBV, Universite de Montreal, (4)Chimie, Universite de Montreal

Per- and polyfluoroalkyl substances (PFAS) comprise a large family of synthetic fluorinated compounds widely used in industrial and consumer products because of their hydrophobic, lipophobic, and heat-resistant properties. However, their exceptional chemical stability and environmental persistence have raised major

concerns regarding their potential impacts on human health, wildlife, and ecosystem functioning. Due to their high mobility and resistance to degradation, PFAS are now frequently detected in soils, water, and the atmosphere. Landfill leachates represent a significant and still poorly controlled source of PFAS contamination. The proposed project investigated the distribution and accumulation dynamics of PFAS in seven fast-growing willow (Salix spp.) varieties irrigated with contaminated water simulating a mixture of PFAS commonly found in landfill leachates, with the objective of evaluating their potential for phytofiltration applications.

Mesocosm experiments were conducted to characterize PFAS distribution in plant tissues and soil matrices, and to examine how PFAS physicochemical properties influence their transfer and accumulation. PFAS concentrations in plant samples were quantified using liquid chromatography coupled with mass spectrometry (LC-MS). Although PFAS treatments did not induce significant differences between treated and control willows, significant inter-varietal differences were observed in PFAS accumulation and translocation patterns, with the highest concentrations consistently detected in leaves. Our results further suggest that PFAS physicochemical characteristics, particularly carbon chain length and functional group type, strongly influence their mobility, transfer, and accumulation within willow tissues. Overall, this controlled-environment study demonstrates the promising potential of willow-based filtration plantations as a biological treatment strategy for PFAS-contaminated landfill leachates.

6.03.P-Tu026 Sustainable Remediation via Engineered Microbial Fermentation: Valorization of Groundnut Shell Agro Wastes to Bioethanol

IRENE OHANUSI[1], Campbell Akujobi[2], Braide Wesley[2] and Chijioke Emenike[3] (1)1Department of Microbiology, Hezekiah University, Umudi,Imo state Ngeria, (2)2Department of Microbiology, Federal University of Technology, Owerri, Nigeria, (3)3Department of Plant, Food, and Environmental Sciences, Dalhousie University, Canada

Agro-waste accretion constitutes a persistent environmental burden, particularly in regions lacking sustainable waste management strategies. This study explores the remediation potential of Groundnut shell (Arachis hypogea) residues through its conversion into bioethanol, integrating waste reduction with renewable energy generation. A novel Aspergillus niger isolate (HEFAPhR) and Saccharomyces cerevisiae were employed in fermentation processes, following enzymatic pretreatment with cellulase to release fermentable sugars. Using a Box-Behnken design to optimize parameters—substrate weight, pH, inoculum size, temperature, and fermentation time—bioethanol yields were maximized under controlled conditions. Notably, A. niger HEFAPhR produced 3.6397 ml ethanol from Groundnut shell waste under optimal conditions (pH 6.0, 30°C, 5% inoculum, 10g substrate, 96h), outperforming S. cerevisiae (0.5237 ml). This approach highlights a low-cost, biologically driven remediation strategy that not only mitigates agro-waste pollution but also contributes to green energy development. The integration of microbial biotechnology and environmental engineering offers a viable path for restoring ecological integrity while supporting circular bioeconomy initiatives.
Keywords: Agro-waste remediation, Groundnut shell waste, Bioethanol, Environmental engineering, Aspergillus niger, Fermentation, Circular economy

6.03.P-Tu027 Evaluating Powderized Adsorptive Amendments for the In-Situ Immobilization of per- and Polyfluoroalkyl Substances in Aquatic Sediments

Nicholas Hayman[1], Josiah Discar[2], Molly Colvin[1], Jessica Carilli[2], Moses Ajemigbitse[3] and John Collins[4] (1)Naval Information Warfare Center Pacific (NIWC Pacific), (2)Naval Information Warfare Center Pacific, (3)Aquablok, (4)AquaBlok

Per- and polyfluoroalkyl substances (PFAS) are ubiquitous environmental contaminants representing significant financial liabilities for remediation. While remediation efforts have primarily focused on impacted groundwater and surface water, PFAS may also accumulate in sediments. Typically, PFAS are transported to sediments via surface runoff or groundwater-surface water interfaces (GSI), where they can bioaccumulate in benthic organisms, serving as a vector to the broader biological system. Consequently, in-situ immobilization of PFAS in sediments is critical to mitigating transfer into biological systems. This project evaluates four powderized sorbents (activated carbon, an activated carbon/aluminum hydroxide blend, a modified organoclay, and a cyclodextrin-based sorbent) for deployment via a mature delivery system that coats aggregate particles with the adsorptive amendments. This approach offers a highly cost-effective and minimally disruptive alternative to traditional dredging and capping. We will present results from both an initial laboratory study using spiked seawater and freshwater solutions to assess capacity of each sorbent, and a comprehensive bioaccumulation assay scheduled for completion this summer. The bioaccumulation assay will utilize real-world sediments amended with each adsorptive mixture. Following an equilibration phase, we will conduct freshwater- or saltwater-specific amphipod toxicity and annelid bioaccumulation assays (depending on sediment source) across all treatments. These results will identify the most effective sorbents for immobilizing PFAS in sediments, with the optimal site-amendment combinations advancing to a larger mesocosm-scale field study. Ultimately, utilization of adsorptive amendments to remediate impacted sediments will reduce PFAS transfer to aquatic food webs, mitigating ecological and human health risks at impacted sites.

Disclaimer/Disclosure: The project is funded by the Navy Environmental Sustainability Development to Integration Program (Project 637)

6.03.P-Tu028 Rapid Assessment of Novel Sorbents in the Field

Nicholas Hayman[1], Josiah Discar[2], Jessica Carilli[2], Robert George[2], Mario Malfavon[2], Nadezda Ojeda[3], Edward Hart[3] and Alexis Wells-Carpenter[3] (1)Naval Information Warfare Center Pacific (NIWC Pacific), (2)Naval Information Warfare Center Pacific, (3)AxNano

Per- and poly-fluoroalkyl substances (PFAS) are environmentally widespread chemicals that will likely cost billions of dollars to remediate. Sorbents are one of the most mature treatment technologies , and have been used to remove PFAS from groundwater, surface water, and porewater. Different sorbents are more or less effective based on site-specific water quality parameters such as salt content, organic carbon, and PFAS composition. Thus, there is a need to test sorbent efficacy using site waters. We will present two case studies using the NIWC Pacific developed Sorbent Onsite Testing Apparatus (SOTA), which allows for the rapid site-specific evaluation of different sorbents by effectively bringing laboratory column testing into the field. First, data from the SOTA unit will be compared to data from a traditional, pilot scale water treatment system at a California groundwater site. A total of four sorbents (activated carbon, an anion exchange resin, a modified organic clay, and a cyclodextrin based sorbent) were evaluated simultaneously, and their relative performance

will be compared. In the second case study, results from a co-deployment of SOTA and a full-scale mobile sorbent treatment system (AxTract from AxNano) will be presented for treatment of PFAS-impacted investigation-derived waste (IDW) at four sites. These case studies not only allow for comparisons of the efficacy of multiple sorbents using real-world waters, they also demonstrate and validate a novel field methodology to predict performance of pilot- and full- scale systems. The effort and cost associated with full scale remediation of PFAS (i.e., pump and treat systems, in-situ sorbent amendment placement) is very high; therefore, assessment of sorbent efficacy for the wide variety of PFAS constituents in groundwater at a given site should be known before investment is made to install a particular treatment system. Determining which treatment materials are most likely to mitigate PFAS at a given impacted site will prevent the installation of a sub-optimal treatment, representing significant cost savings and better remediation outcomes.

Disclaimer/Disclosure: This project is funded by the Environmental Security Technology Certification Program (Project ER24-8303) and the Navy Environmental Sustainability Development to Integration (Project 578)

6.03.P-Tu029 Where the Crayfish Swim: Assessing Wetland Restoration in the Mississippi Alluvial Plain Using Biotic and Physicochemical Indicators

Helena Wheeler[1], Taylor Thomisee[2], Colin Dobson[2], Sarah Webb[2] and Jennifer Bouldin[2] (1)Texas Tech University, (2)Arkansas State University

The Mississippi Alluvial Plain has lost approximately 80% of naturally occurring wetlands since the 19th century, due to urbanization and agriculture. This loss reduced the land's ability to cycle and detoxify nutrients and other contaminants. To address this, the U.S. government established the Wetland Reserve Program, now the Agricultural Conservation Easement -Wetland Reserve Easement Program (ACEP-WRE) in 1990, to incentivize landowners into converting their property into wetland habitat. Since then, 11,736 km2 of wetland habitat has been restored. However, despite the program's 35-year-old tenure, there is limited research comparing the functional similarity of ACEP-WRE sites to natural wetlands.

This project compared biogeochemical and ecological similarity of ACEP-WRE wetlands (n=30) within Arkansas to agricultural control sites (n=5) and natural reference bottomland hardwood forest wetlands (n=5). Each site was sampled quarterly at three locations. Sampling occurred between February 2024 and June 2025, with collection including water, soil, aquatic macroinvertebrates, and hydrophytes; surveys were also conducted for amphibians and birds. Water samples were analyzed for physicochemical properties, turbidity, suspended sediments, and nutrient concentrations. Soil samples were analyzed for metals, organic material, and physicochemical properties. Macroinvertebrate diversity and community composition were calculated for each site. Avian and amphibian communities were characterized for each site and compared among habitat types.

Data supported ACEP-WRE wetlands' efficacy in cycling nutrients and supporting macroinvertebrate diversity comparable to or greater than natural wetlands. Additionally, ACEP-WRE wetlands were found to effectively host amphibian and avian communities, with greater habitation by wetland specialists than in agricultural control sites. These findings support the notion that the ACEP-WRE program effectively restores wetland habitat and functionality within northeast Arkansas. Finally, this study provides a framework for future studies to determine the functional abilities of constructed wetlands and further inform wetland restoration.

6.03.P-Tu030 Enhanced Stabilization of Hydrocarbons in Industrial Soils Treated With an Innovative Low-Carbon Binder for Rapid Site Remediation and Repurposing

Akhila Thomas Choondal[1], Nikolas Romaniuk.[2] and Wonjae Chang[1] (1)University of Saskatchewan, (2)GRAYMONT

In Western Canada, the energy sector faces challenges in remediating and repurposing numerous abandoned oil and gas sites and industrial brownfields. Remaining inactive sites continue to contaminate groundwater and surface waters and emit greenhouse gases. Green remediation approaches aim to remediate contaminated sites while reducing hydrocarbon emissions from cleanup activities, such as excavation and soil transport, while maintaining cost efficiency. Many legacy sites are highly aged, with residual hydrocarbons that hinder bioremediation. Biodegradation endpoints are unpredictable, especially when contaminants are strongly sorbed or sequestered, even if still extractable. Lime-based binders are commonly used for in-situ solidification/stabilization (S/S), but their effectiveness in treating aged, hydrophobic hydrocarbons under field conditions has been insufficiently studied. This study aims to develop a rapid, low-carbon in-situ S/S technique for remediating and repurposing hydrocarbon-impacted industrial sites, particularly as a post-bioremediation approach. Batch-scale S/S experiments were conducted to evaluate various secondary binders, including a novel low-carbon aluminosilicate binder, zeolite, kaolinite, montmorillonite, biochar, activated carbon, and natural clays/silts. Among the binders tested, the low-carbon binder and zeolite showed comparable performance, with stronger hydrocarbon binding and lower emissions than other materials, including activated carbon. However, zeolite required activation from supplemental quicklime, whereas the low-carbon binder, a pozzolanic cementitious binder itself, did not. Column leaching and desorption tests indicated negligible hydrocarbon loss to water in successfully treated soils. Notably, oxygen-containing hydrocarbons were detected in the S/S-treated soil matrix. These hydrocarbons required two additional solvent-extraction steps to detect, beyond standard methods, indicating enhanced immobilization and stabilization through interactions with inorganic mineral products. Overall, hydrocarbon partitioning analysis suggested that the new low-carbon binders and zeolite are promising for site remediation and for repurposing hydrocarbon-impacted soils. Further research will explore inorganic-organic binding mechanisms and reductions in hydrocarbon emissions.

Disclaimer/Disclosure: Mitacs Accelerate Cleantech Grant, IT38657 (Wonjae Chang), Graymont (Wonjae Chang), NSERC Discovery Grant, RGPIN 06144-2020 (Wonjae Chang)

General: Environmental (Human and Ecological) Risk Assessment

5.10.P-We126 Concentration of Polycyclic Aromatic Hydrocarbons in Agricultural Soils and Their Potential Health Risk Assessment

Muhammad Saleem[1], Simon Vojta[2], Thomas Garrow[2], Rainer Lohmann[2], Tehreem Lashari[1], Donald A. Sens[1], Seema Somji[1] and Scott H. Garrett[1] (1)University of North Dakota, (2)The University of Rhode Island

Polycyclic aromatic hydrocarbons (PAHs) are a group of organic pollutants that impact environmental and public health due to their toxicity, persistence and bioaccumulate nature. Thirty soil samples were collected to assess PAHs contamination in agricultural soils amended with biological, inorganic, and organic fertilizers, and analyzed by GC-MS. Most low-molecular-weight PAHs (e.g., naphthalene, methylnaphthalenes, and biphenyl)

were below detection limits (<500 pg/g), indicating limited petrogenic inputs. In contrast, high-molecular-weight PAHs such as fluoranthene, pyrene, chrysene, benzo(b)fluoranthene, and benzo(a)pyrene were dominant, with total PAHs concentrations ranging from approximately 1100 to 23,000 pg/g. The dominance of 4-6-ring PAHs in soils suggests that PAHs are generally associated with fossil fuel combustion. Soils amended with biological and inorganic fertilizers had higher PAHs concentrations compared to organic fertilizers, likely due to lower microbial degradation and lower organic matter. A human health risk assessment was performed by using benzo(a)pyrene toxic equivalency factors (TEFs) which indicated that carcinogenic PAHs contribute most significantly to potential exposure risks. The total BaPeq indicated the cumulative carcinogenic potential of the PAH mixtures, with higher contributions from 4-6-ring PAHs such as Chrysene, Benzo(a)pyrene and Indeno(123cd)pyrene. Incremental Lifetime Cancer Risk (ILCR) calculations suggested that several samples exceeded the negligible risk threshold (1 × 10-6), highlighting potential human health concerns. These results suggest the importance of regular PAHs monitoring especially high-molecular-weight PAHs to minimize PAHs accumulation and associated health risks.

5.10.P-We128 Maternal Inflammatory and Vascular Mechanisms Linking Air Pollution Exposure to Preterm Birth in the MIREC Study

Juwel Rana[1], Mandy Fisher[2], Markey Johnson[3], Krishna Priya Syama[2], Erica Blais[2], Eric Lavigne[2], Chintan K Gandhi[4], Michael M. Borghese[2], Jillian Ashley-Martin[2], Tye E. Arbuckle[2], William Fraser[5] and Premkumari Kumarathasan[6] (1)Environmental Health Science and Research Bureau, Healthy Environments and Consumer Safety Branch (HECSB), Health Canada, Ottawa, ON, Canada, Deparment of Epidemiology, Biostatistics and Occupational Health, McGill University, Montreal, Canada, (2)Environmental Health Science and Research Bureau, Healthy Environments and Consumer Safety Branch (HECSB), Health Canada, Ottawa, ON, Canada, (3)Water and Air Quality Bureau, Healthy Environments and Consumer Safety Branch (HECSB), Health Canada, Ottawa, ON, Canada, (4)Department of Pediatrics, Penn State University, State College, Pennsylvania, USA, (5)Centre Hospitalier Universitaire de Sherbrooke, Sherbrooke & CHU Sainte-Justine, Montreal, QC, Canada, (6)Environmental Health Science and Research Bureau, Healthy Environments and Consumer Safety Branch (HECSB), Health Canada, Ottawa, ON, Canada, Interdisciplinary School of Health Sciences, Faculty of Health Sciences, University of Ottawa, Ottawa, ON, Canada

Air pollutants have been reported to trigger oxidative stress, perturbing inflammatory and vascular pathways; however, the toxicity mechanisms by which air pollution affects preterm birth remain unclear. To investigate maternal inflammatory and vascular biomarkers as potential mediators of associations between prenatal air pollution exposure and preterm birth. Analyses were conducted using data from the Maternal-Infant Research on Environmental Chemicals (MIREC) study, a Canadian prospective pregnancy cohort (n=1049). Maternal plasma inflammatory (e.g., cytokines, chemokines) and vascular effect markers (e.g., endothelins) in 3rd trimester were analyzed using multiplexed affinity proteomics and HPLC-fluorescence, respectively. Air pollution exposures (PM2.5, NO2, O3, and SO2) during the third trimester of pregnancy were linked to maternal residence during pregnancy. Generalized estimating equation, parametric gformula methods as well as causal mediation analysis were used to examine the associations between air pollutants, maternal biomarkers, and preterm birth. 4.8% of deliveries were preterm birth. Air pollutants were associated with biomarkers and an increased risk of preterm. For instance, exposure to PM2.5 was associated with risk of preterm birth (OR = 1.30; 95% CI: 1.04, 1.62). A joint increase in four inflammatory biomarkers (Interleukin-IL8, Interleukin-10, Interferon-gamma, and C-reactive protein) by one quartile was associated with higher odds of preterm birth (OR=1.91; 95% CI: 1.34, 2.70). Similarly, one-quartile joint increase in endothelin-related biomarkers (BET1,

BET2, ET1, ET2, ET3) was associated with higher odds of preterm birth (OR=2.19; 95% CI: 1.39, 3.46). Among the six inflammatory mediators examined, IL-8 showed the strongest evidence of mediation, with a marginally significant pure natural indirect effect (NIE = 1.07, 95% CI: 1.00, 1.19, p = 0.084), accounting for approximately 13% of the total PM2.5–preterm birth association. BET1 showed a similar pattern (NIE = 1.09, p = 0.104, proportion mediated = 18%).
Our findings suggest a potential role of maternal inflammation in the relationship between air pollution exposure and preterm birth. Future analyses will explore toxicological pathways in relation to additional maternal and fetal pregnancy outcomes.

5.10.P-We129 Mining Proximity and Tissue-Mercury Concentrations in Freshwater Fish in Subarctic Canada: A Bayesian Modelling Approach

Robert Moriarity[1], Kirill Zakharov[1], Fatima Ahmed[2], Leonard Tsuji[2] and Eric Liberda[2] (1)Toronto Metropolitan University, (2)University of Toronto

Fish tissue-mercury (Hg) varies by species, size, and local environmental conditions that affect Hg bioavailability. In Eeyou Istchee, northern Quebec, Canada, the relationship between mining proximity and fish tissue-Hg remains poorly characterized despite intensive mining in the region. We analyzed 584 fish tissue-Hg observations from 50 waterbodies and 8 fish species near Oujé-Bougoumou Cree First Nation. A geographic information system was used to classify waterbodies by mining proximity. We fit an integrated Bayesian hierarchical model that accounted for fish size, species-level variation, species-specific mining-proximity responses, and lake-level clustering. Fish from waterbodies classified as mining-proximal using the primary 15 km proximity definition had an estimated 1.56-fold higher tissue-Hg concentration than fish from non-mining-proximal waterbodies (95% credible interval: 1.21 to 1.98; posterior probability $\beta > 0 = 0.998$). The association was similar when mining proximity was defined within 5 km and weaker when defined within 30 km. Mining proximity was associated with higher fish tissue-Hg in Oujé-Bougoumou waterbodies, supporting further site-specific monitoring and human health risk assessments where local fish harvesting occurs.

5.10.P-We130 Refining the Nickel Ecological Soil Screening Level for Insectivorous Mammals

Kyle Fetters[1] and Phyllis Fuchsman[1] (1)Ramboll

Nickel (Ni) is a naturally occurring metal widely used in industry and an essential trace element for many organisms. Ecological Soil Screening Levels (Eco-SSLs) are guidance values used to identify soil contaminant concentrations that are unlikely to pose ecological risk. However, the United States Environmental Protection Agency (EPA) did not establish a mammalian insectivore (e.g., shrew) Eco-SSL for Ni due to insufficient data on Ni bioaccumulation from soil to invertebrate prey. This resulted in a critical data gap, leaving risk assessors without a screening value for small mammalian predators of invertebrates. To address this gap, we evaluated available Ni bioaccumulation and toxicity data and explored refined assumptions for Ni exposure. We compiled soil-to-earthworm Ni uptake data from recent studies to characterize Ni bioaccumulation in a worst-case prey species (earthworms) for insectivorous mammals. We also examined Ni bioaccumulation in aboveground invertebrates as an additional line of evidence because many of these invertebrates accumulate significantly less Ni. We also considered the relative bioavailability of Ni in soil and dietary items to better estimate the fraction of ingested Ni that would be absorbed by mammals in the environment as compared to toxicity studies

administering Ni via water. Further, we reviewed mammalian Ni toxicity studies underlying the current toxicity reference value (TRV), focusing on study design and endpoint relevance as well as interspecies extrapolation methods. By integrating more realistic nickel bioaccumulation factors, diet composition, relative bioavailability, and robust toxicity reference values, this analysis explores refined screening values for Ni that are realistic yet still protective. This work should help risk assessors identify Ni-contaminated soils of true ecological concern while avoiding unwarranted concern at background or low-end contamination levels. Additional research on Ni uptake differences among invertebrate prey and Ni bioavailability in mammals could help further reduce remaining uncertainties in these exposure pathways.

5.10.P-We131 Anthropogenic Signatures of Parabens and Heavy Metals in Indoor Dust: Evidence and Multivariate Insights From a Nigerian Urban Environment

Olumuyiwa Ogunlaja[1], Caroline Idogar[1], Oluwasegun Amoniyan[1] and Abdul Ishola[2] (1)Lead City University, (2)Department of Industrial Chemistry, University of Agriculture and Development Studies, Iragbiji, Osun State

Indoor dust serves as a reservoir for hazardous pollutants, including parabens and heavy metals, which may threaten human health. However, information on their co-occurrence and associated risks in Nigeria remains limited. This study determined the concentrations of four parabens—methylparaben (MeP), ethylparaben (EtP), propylparaben (PrP), and butylparaben (BuP)—and selected heavy metals (Cu, Mn, Pb, Zn, Cr, Ni, and Cd) in 120 indoor dust samples collected from residential environments in Ibadan, Nigeria, using HPLC-UV and atomic absorption spectrophotometry. Analytical validation showed excellent recoveries (above 99.9%) and strong linearity ($R^2 > 0.999$). Human exposure risk was assessed using estimated daily intake (EDI). All analytes were detected in most samples, indicating widespread contamination. Median paraben concentrations decreased in the order MeP > EtP > BuP > PrP, with MeP accounting for 52% of total parabens. Heavy metals followed the order Mn > Zn > Cu > Pb > Ni > Cr > Cd. The geometric mean concentration of total parabens exceeded values reported in several countries, suggesting elevated contamination likely associated with personal care product usage. Although hazard quotient values indicated low non-carcinogenic risk, the co-occurrence of these contaminants underscores the need for continuous environmental monitoring and preventive public health measures.

5.10.P-We132 Occurrence and Exposure Assessment of Antibiotics, Parabens, and Potentially Toxic Elements in Groundwater Sources From Two Rural Communities in Nigeria

Olumuyiwa Ogunlaja[1], Oluwakemi Akintobi[2], Adesola Adedeji[3], Aemere Ogunlaja[4] and Olusola Ladokun[1] (1)Lead City University, (2)University of KwaZulu-Natal, (3)Institute for Advanced Medical Research and Training (IAMRAT), College of Medicine, UCH, Ibadan, (4)Redeemer's University, Ede, Osun State

The presence of emerging organic contaminants (EOCs) and potentially toxic elements in groundwater is a global concern. In Nigeria, however, monitoring and risk assessment data for EOCs such as Methylparaben (MeP), Ethylparaben (EtP), Propylparaben (PrP), Butylparaben (BuP), and antibiotics like ampicillin, chloramphenicol, ciprofloxacin (CIP), and metronidazole (MET) are scarce, especially in rural areas. This study quantified EOCs and metals in groundwater from two rural Nigerian communities using high-performance liquid chromatography-UV and inductively coupled plasma optical emission spectroscopy, with validation through recovery (99.6%–101%) and linearity (R2 > 0.999). Health risks were assessed via target hazard

quotient (THQ), target carcinogenic risk (TCR), and risk quotient (RQH). The groundwater samples followed the decreasing order: Ca > Mg > Na > K > Co > Al > Fe > Cr > Mn > Zn > Cd > Ni > Pb > B > Cu > Se for metals and MET > CIP > BuP > MeP > PrP > EtP for EOCs. Groundwater EOC concentrations were as high as 7,846 (MET), 1,137 (CIP), 342 (MeP), 295 (EtP), 299 (PrP), and 400 μg L−1 (BuP), while Fe, Zn, Al, Cr, Ni, and Pb in all groundwater samples investigated were higher than the permissible limit recommended by the World Health Organization. The human risk assessment revealed both noncarcinogenic and carcinogenic hazards from Cd, Cr, Ni, and Pb, with Cr contributing approximately 90% of the cumulative THQ and TCR. Additionally, CIP exhibited high RQH (>1) across all age groups, ranging from 1.142 to 49.174. Findings from this study indicate that groundwater consumption in these communities poses significant health risks.

5.10.P-We133 Inventory of Commercial Chemicals in Africa: Temporal Trend and Hazard-Based Prioritization for Environmental Risk Assessment

Richard Boadu Opoku[1] and Xianming Zhang[2] (1)Concordia Univeristy, (2)Concordia University

The global chemical industry encompasses over 350,000 commercial substances, many of which are traded internationally through expanding global supply chains, making the movement of chemicals across borders a key driver of environmental exposure worldwide. Industrialized regions including North America, Europe, East Asia, and Oceania have chemical inventories, but Africa's data coverage, assessments, and regulatory systems are limited. To address this knowledge gap, we compiled annual chemical trade data for the 54 African countries from 1996 to 2024, covering five chemical classes defined by six-digit Harmonized System (HS) codes. Each class, representing multiple individual chemicals, was analyzed using temporal trend clustering to identify rapidly increasing classes, which were then ranked by their 2024 trade quantities. To enable hazard quantifications, individual chemicals (CAS registry numbers and SMILES structures) within each class were extracted from the PubChem databases. The study assessed 91 isocyanates and their transformation products for persistence, bioaccumulation potential, mobility, and biomagnification using an in-silico approach (EPI Suite). The results revealed that 11% of the isocyanate chemicals and 6% of the transformation products had a bioaccumulative factor exceeding the threshold (2000 L/kg wet-wt). 71% of the isocyanate compounds and 93% of the transformation products demonstrated biomagnification potential. Mobility assessments showed that 23% of the isocyanate chemicals and 57% of the transformation products had log Koc values exceeding the threshold (Log Koc < 3), suggesting a potential elevated mobility in environmental media and a corresponding risk of groundwater contamination. Biodegradation modeling under aerobic conditions indicated that more than half of the commercial isocyanate chemicals and their associated transformation products are likely to be biodegradable. Taking into account these relative environmental risk indicators highlights the need for a systematic, supportive framework to identify and prioritize chemicals requiring regulatory intervention. Practical measures, including the establishment of a chemical inventory among African countries, will serve as a surveillance for the management and regulation of commercial chemicals to minimize ecological risk.

5.10.P-We134 Review of Marine Predicted No Effects Concentration for Vanadium

Jack (Jay) Word[1] and William Stubblefield[2] (1)Spheros Environmental, (2)Oregon State University

When evaluating risk to the aquatic environment from a specific constituent, often using established chemical specific regulatory values are a good way to start. These values provide benchmark concentrations that, if

complied with, should prove environmentally safe; however, if exceeded, may suggest elevated risk to the aquatic environment. In the United States, federal numeric ambient water quality criteria or state standards can be used for this purpose. Although numeric criteria/standards have been created for many contaminants, they don't exist for all of them. Vanadium (V) is one metal that does not have a U.S. criterion or standard.

Other jurisdictions have developed similar benchmark concentrations, e.g., in Europe, the European Chemicals Agency (ECHA) reported a marine Predicted No-Effect Concentration (PNECs) for vanadium of 2.5 µg V/L, a value derived from three toxicity studies. The most sensitive endpoint identified was a single study evaluating toxicological responses in the Pacific oyster, Crassostrea gigas. However, review of this study identified several methodological limitations that raise uncertainty regarding the reliability of the reported results and, consequently, their suitability as the basis for deriving a benchmark concentration.

Robust benchmark values are essential for accurate vanadium (V) risk assessments. In 2025, we reevaluated the study used to derive the marine PNEC by conducting toxicity tests with marine bivalves, including C. gigas, using current state-of-the-science methods with analytically verified exposure concentrations and well-defined concentration–response relationships. The original study was "unbounded", preventing direct calculation of a No Observed Effect Concentration (NOEC). Nevertheless, a NOEC of 25 µg V/L was estimated during PNEC derivation as one-half of the lowest test concentration. In contrast, our study found a lowest NOEC of 612 µg V/L for C. gigas based on the proportion-normal endpoint, indicating substantially lower sensitivity than previously reported.

Additionally, the NOEC is not the preferred endpoint to use when deriving a PNEC; an EC10 (calculated effect level that affects 10% of the test organisms) is generally recognized as preferred. If we developed the PNEC using the lowest EC10 (1,385 µg V/L; C. gigas combined proportion normal) using the same assessment factor, the PNEC for vanadium in the marine environment would be 138.5 µg V/L).

5.10.P-We135 Irgarol-Induced Transcriptional Changes in Energy Metabolism Genes of the Mud Crab Macrophthalmus japonicus

Ihn-Sil Kwak[1] and Kiyun Park[1] (1)Chonnam National University

Antifouling paints are biocidal products applied to surfaces of boats, ships and aquatic structures in order to prevent the growth and settlement of marine organisms, usually by the release of a biocide. Irgarol is a highly effective biocide used in antifouling coatings to prevent the growth of periphyton. Irgarol and its photodegradation products are highly persistent in waters and sediments. In the study, we aimed to determine the potential effects of irgarol exposure at the transcriptional level in Macrophthalmus japonicus, a highly dominant crab species in estuaries. To this end, we characterized the M. japonicus arginine kinase (AK) gene, which plays a role in energy metabolism in invertebrates, and examined its expression levels in response to irgarol exposure. Consequently, AK was identified as a highly prevalent enzyme in invertebrate species, including crustaceans and insects. Following irgarol exposure, the gills of M. japonicus exhibited relatively elevated AK gene expression compared to the control group at 4 and 7 days of exposure. In addition, elevated AK gene expression was observed in the hepatopancreas. Notably, the relatively low irgarol exposure concentrations of 1 and 10 µg L−1 demonstrated comparatively higher AK gene expression in the hepatopancreas than the relatively high irgarol concentration of 30 µg L−1. The results of this study imply that

irgarol exposure may disrupt the equilibrium of energy metabolic processes regulated by AK gene expression in the M. japonicus crab. Moreover, the sustained environmental accumulation of irgarol indicates that it may serve as a significant disturbance factor within estuarine ecosystems.

5.10.P-We137 Fibrous Microplastic-Induced Toxicity in the Intertidal Mud Crab (Macrophthalmus japonicus): Bioaccumulation, Histopathological Change, and Antioxidant Responses

Kiyun Park[1], Ji-Hoon Kim[1], Joo-Yeon Kang[1] and Ihn-Sil Kwak[1] (1)Chonnam National University

Microplastics (MPs) have gradually become major global concerns, due to the widespread use of plastics. The accumulation of MPs in estuarine regions and their ecological consequences have become global environmental concerns, but data on the impact on organisms is still not sufficient. Fibrous MPs are dominantly detected in aquatic water and sediments. This study examined the toxic effects of fibrous MP on survival, bioaccumulation, histological changes, and antioxidant defense in the intertidal mud crab Macrophthalmus japonicus. The survival rate declined more significantly following exposure to small fiber MPs than to large ones. Gills accumulated more MPs than the hepatopancreas and stomach. Bioaccumulation levels were generally higher for small fiber MPs than for large ones. The accumulation of the small fiber MPs was highest at 7 days across all tissues, whereas MP accumulation of the large fiber was highest at 4 days in the gills and stomach. Morphological alterations of fibrous MPs were observed within crab tissues following uptake. Exposure also induced histological damage in gills, such as swelling of the gill filaments, and resulted in time-dependent changes in antioxidant enzyme activity. Overall, small fiber MPs exhibited greater toxic effects compared to large ones. Our findings highlight the environmental risks associated with fibrous MP exposure in benthic crustaceans such as M. japonicus, which serve as important indicators for monitoring food web health and ensuring seafood safety for human consumption.

5.10.P-We138 Mercury Exposure and Health Risk From Fish Consumption in Proximity to Mining Activity

Kirill Zakharov[1], Fatima Ahmed[2], Eric Liberda[2] and Robert Moriarity[1] (1)Toronto Metropolitan University, (2)University of Toronto

Mercury (Hg) exposure from fish consumption is a risk to human health in Oujé-Bougoumou Cree First Nation, where harvested fish include species from waterbodies in proximity to intensive mining activity. This study estimated the non-carcinogenic exposure risk (HQi) to Hg from fish consumption using 400 fish tissue-Hg samples from seven species of fish. Monte Carlo (MC) simulations for variability were used to estimate risk by consumer group, fish species, and size class. Uncertainty MC models evaluated the most influential exposure parameters identified by the variability MC models. Women had the highest estimated risk in the variability simulations, with large pike and large walleye yielding HQi of 2.62 and 2.63, respectively. In the uncertainty analysis, the risk threshold for Hg was exceeded in 59% of large pike consumption simulations and 55% of large walleye consumption simulations. Seasonal modelling indicated a higher summer exposure risk due to increased consumption frequency. Risk-benefit analysis showed that some smaller predatory fish retained dietary value despite elevated tissue-Hg. The results also identify species-size groups that should be prioritized in a future baseline assessment before mining remediation-related changes are evaluated.

5.10.P-We139 Ethylene Oxide and Human Cancer Risk Assessment: A Comparison of Parametric and Non-Parametric Dose Response Modeling Approaches

Margaret Whittaker[1] (1)ToxServices LLC

Ethylene oxide (CAS#75-21-8) is a colorless gas that among other industrial uses, is used to sterilize medical devices. Its use as a medical device sterilant is widespread, and more than 20 billion medical devices are sterilized with ethylene oxide annually in the United States. Multiple authoritative bodies classify ethylene oxide as a GHS Category 1B germ cell mutagen (H340) and Category 1B carcinogen (H350) (among other health hazards, such as reproductive and developmental toxicity (H360Fd)). Release of ethylene oxide within and around industrial facilities must be tightly controlled due to this chemical's potential toxicities. Despite controls mandated by U.S. EPA Hazardous Air Pollutant (HAP) classification of ethylene oxide, which mandates specific control technologies, over 14 million people in the United States live within five miles of a facility that releases ethylene oxide into ambient air. Two separate agencies (the U.S. Environmental Protection Agency and the Texas Commission on Environmental Quality, TCEQ) assessed ethylene oxide cancer risk using the same two high-exposure occupational cohorts, but arrived at very different cancer risk values based on the selection of specific cancer types (e.g., breast cancer and/or lymphoid cancer), cancer endpoints (cancer incidence vs. cancer mortality), and application of different dose-response models. This presentation compares and contrasts U.S. EPA's vs. TCEQ's selection of cancer datasets and application of parametric (standard Cox proportional hazards model) vs. nonparametric (linear two-piece spline model) dose-response models in the assessment of cancer risk, with the goal of identifying best practices in cancer risk assessment methods for the protection of public health.

5.10.P-We140 Using U.S. EPA's Ecological Structure Activity Relationships Tool in Tandem With Their Ecotoxicology Knowledgebase To Screen per- and Polyfluoroalkyl Substances in Ecological Risk Assessment

Natasha Vozenilek[1] and Heather Loso[1] (1)AECOM

Per and polyfluoroalkyl substances (PFAS) are persistent chemicals which, once in the aquatic environment, may cause several adverse reproductive and developmental effects including endocrine disruption, histopathological and behavioral changes in exposed aquatic species. Numerous factors contribute to the toxicity potential of these PFAS on aquatic species, including source of inputs, environmental conditions (e.g., turbidity, dissolved organic carbon, salinity, pH temperature, etc.), PFAS chain length and functional group, species sensitivity, and whether these PFAS exist as single compounds or mixtures in aquatic environments.

The Ecotoxicology Knowledgebase (ECOTOX) is a database maintained by the U.S. Environmental Protection Agency (USEPA) that focuses on the effects of various chemicals on terrestrial and aquatic organisms (e.g., fish, invertebrates, algae, terrestrial plants, and soil organisms) using various toxicity endpoints. There are hundreds of PFAS in ECOTOX for which published information on toxicity endpoints, affected species, and effect measurements can be found, and research is on-going to fill empirical data gaps. Where these data gaps arise, the Ecological Structures Activity Relationships (ECOSAR) software may be used as a supplemental screening tool. ECOSAR is a software program developed by the USEPA that predicts acute and chronic toxicity based on chemical structure and allows for the calculation of aquatic screening levels for chemicals that lack them in the readily available literature. Like ECOTOX, ECOSAR may predict toxicity for various

terrestrial and aquatic organisms for chemicals where experimental data may not yet exist, allowing for early environmental risk determination.

The overarching objective of this presentation is to provide a basis for utilizing both qualitative and quantitative data from ECOSAR and quantitative data from ECOTOX in tandem when screening PFAS in an ecological risk assessment. The following comparisons will be explored: 1) how screening levels obtained from ECOSAR compare to published values for select PFAS, and 2) how screening levels obtained from ECOSAR for PFAS without published screening values compare to ECOTOX values.

5.10.P-We141 Genetic Variability in GSTM1 Influences Arsenic Methylation Efficiency in a Colombian Population Chronically Exposed to Contaminated Groundwater

Farith Gonzalez-Martinez[1], Sindy Mendoza-Caro[1] and Boris Johnson-Restrepo[1] (1)University of Cartagena

Exposure to inorganic arsenic through contaminated groundwater is a major public health concern worldwide because of its well-established toxicity and carcinogenicity. Individual susceptibility to arsenic-related health effects varies considerably and may be influenced by both environmental exposure and genetic factors involved in arsenic metabolism. However, the contribution of genetic polymorphisms to arsenic methylation efficiency in exposed populations remains insufficiently understood.

This study investigated groundwater arsenic exposure and its relationship with urinary arsenic metabolism and genetic polymorphisms in residents of Repelón, Atlántico, Colombia. A total of 114 adults (18–81 years) were recruited. Groundwater arsenic concentrations and urinary arsenic species were determined using high-performance liquid chromatography coupled to hydride-generation atomic fluorescence spectrometry. In contrast, polymorphisms in genes associated with arsenic metabolism and detoxification (GSTM1, GSTT1, GSTP1, GSTO2, and AS3MT) were analyzed by polymerase chain reaction-based methods.

Among seven groundwater wells evaluated, two exceeded the World Health Organization guideline value for arsenic, reaching concentrations of 10.7 and 21.1 μg/L. Based on groundwater arsenic concentrations and lifetime average daily dose estimates, participants were classified as exposed (n = 36) or non-exposed (n = 78). The hazard quotient for the exposed group was 1.3, indicating a potential health risk. Exposed individuals exhibited higher creatinine-adjusted urinary concentrations of total arsenic, monomethylarsonic acid, and dimethylarsinic acid than non-exposed individuals. The active GSTM1 genotype was significantly more frequent among exposed participants (63.9%, $p = 0.038$) and was associated with lower urinary concentrations of inorganic arsenic and monomethylarsonic acid, suggesting enhanced methylation efficiency. Multiple regression analysis identified lifetime average daily dose and sex as the principal determinants of arsenic metabolism. These findings indicate that both environmental exposure and genetic variability contribute to interindividual differences in arsenic biotransformation. The results provide evidence that GSTM1 may play an important role in arsenic detoxification and highlight the need to incorporate genetic susceptibility into environmental health risk assessments and mitigation strategies for vulnerable populations.

5.10.P-We142 Health Based Screening Values for Post-Fire Remediation of PAHs in Settled Dust

Theresa Phillips[1] and Stephen Booth[1] (1)Pinchin Ltd.

PAHs were detected in dust that accumulated on surfaces within a high rise building following an adjacent fire, at concentrations above what may be considered background, and health-based screening values for PAHs were required to provide benchmarks for cleanup and reoccupancy. PAHs are a group of chemicals that are formed during the incomplete combustion of materials such as coal, oil, gas, wood, or other organic substances, but are also present in a wide variety of other materials including plastics, which can result in their widespread distribution in the environment following a fire. Certain PAHs are among the most carcinogenic substances identified by the World Health Organization and the US Environmental Protection Agency (EPA) and long-term exposure to these chemicals within an indoor environment can contribute significantly to the overall cancer burden. Post-fire remediation metrics for PAHs in dust have been recommended for inhalation pathways, while risk-based dermal contact and ingestion values are available for combined exposure to both soil and dust. However, little guidance is available with respect to post-fire remedial targets for settled dust in a residential or occupational setting. Risk-based values were derived exclusively for PAHs in settled dust, taking into consideration the model outlined by the United States Environmental Protection Agency when setting health-based benchmarks for dust exposure that arose from the World Trade Center collapse in 2001. Those benchmarks, for settled dust and bulk dust, were specific dermal contact and incidental ingestion pathways in a residential scenario. We incorporated risk assessment guidance from the Ontario Ministry of the Environment Conservation and Parks and adjusted the methodology to address a commercial scenario, such that the screening values could be used as remedial goals and to provide chemical-specific screening criteria protective of the health of workers engaged in remediation.

5.10.P-We143 Human and Ecological Health Risk Evaluation of a per- and Polyfluoroalkyl Substance Free Fire Fighting Foam Alternative

Theresa Phillips[1], Brandi Wilson[1] and Tasha Widmer[1] (1)Pinchin Ltd.

The health effects of per- and polyfluoroalkyl substances (PFAS) on human and ecological receptors is an evolving area of concern for many. As a result, alternatives to PFAS containing foams are being considered as replacements in many industries. This study aimed to determine risk-based screening values to mitigate potential health effects for off-Site human and aquatic receptors from a fluorine-free firefighting foam concentrate being considered for use at a fire-fighting training facility in Southern Ontario. A literature review for toxicity data was conducted for the seven constituent chemicals identified in the product's safety data sheet, focussing on chronic exposure durations and drawing on Canadian and United States regulatory sources, peer-reviewed literature, and accredited databases.

The human risk evaluation concluded all seven constituents of the product are common in both domestically and commercially available household products. No evidence, or no data, were available to show that the seven constituents are carcinogenic, genotoxic, mutagenic, or cause developmental effects. The most significant health effects were assumed to arise from exposure to propylene glycol monobutyl ether, in part because it is present in the product at higher concentrations than the other constituents and partially because the other constituents were anticipated to have lower toxicity. Thus, human health exposure thresholds were developed, for each of the constituents with chronic or sub-chronic toxicity values, resulting in screening values for the individual

constituents that ranged from 0.37 mg/L to 2.15 mg/L.
The aquatic risk evaluation demonstrated that some constituents of the product, particularly long chain aliphatic alcohols, may result in acute or chronic toxicity risks to aquatic organisms at elevated concentrations, with algae and invertebrates identified as the most sensitive trophic groups. However, the overall foam mixture, based on surrogate data for similar fluorine-free formulations, may be expected to exhibit acute aquatic toxicity and limited chronic effects at low concentrations, with toxicity expected to decrease substantially when diluted for use. Thus, aquatic health exposure thresholds were developed, for each of the constituents with chronic toxicity values, resulting in screening values for the individual constituents that ranged from 0.011 mg/L to 136 mg/L.

5.10.P-We144 Global Regulatory Approaches to Microplastics in Drinking Water and the Environment: A Comparative Review

Tamara House-Knight[1] and Francis Ramacciotti[1] (1)GHD

Microplastics, defined by most regulatory bodies as synthetic polymer particles generally less than 5 mm in size, are increasingly detected in surface water and soils, raising concerns about ecological exposure, long term environmental fate, and implications for risk assessment. Despite the increasing presence of microplastics in environmental media, regulatory approaches dealing with microplastic pollution differ substantially across jurisdictions in scope, legal status, and environmental media addressed. In the United States, no numerical toxicity reference values or enforceable federal standards for microplastics in surface water or soil currently exist. Regulatory activity focuses primarily on research and monitoring. The U.S. Environmental Protection Agency (USEPA) has prioritized method development and documenting the presence of microplastics in surface water and sediment and has recently included microplastics on the Safe Drinking Water Act Contaminant Candidate List. However, this action does not establish regulatory limits and does not explicitly address soil media. State level actions, most notably in California, mandate standardized definitions and analytical methods for microplastics in water but do not set concentration based criteria.

Our comparative analysis summarizes regulatory frameworks for microplastics in surface water and soil in the United States (USEPA) with those in the European Union (EU) and Canada, based on publicly available regulatory and scientific sources. Overall, this comparison highlights the gaps between monitoring the presence of microplastics and risk characterization in current frameworks. Most notably, we highlight key implications for environmental toxicology and risk assessment: U.S. approaches currently prioritize scientific characterization over management, whereas European Union policies emphasize precautionary source control with direct relevance to exposure reduction in surface water and soil.

5.10.P-We145 A Conceptual Framework Using Weight-of-Evidence Incorporating New Approach Methods for Risk Assessment

Keith Solomon[1], Alison Pecquet (Willis)[2], Elaine Freeman[3], Shadia Catalano[4], Jyotigna Mehta[5], Tharacad Ramanarayanan[6] and Amber Goetz[6] (1)No Affiliation, (2)Syngenta Ltd, (3)Exponent Inc., (4)Corteva Agriscience, (5)ADAMA Agricultural Solutions, (6)Syngenta Crop Protection

Weight of Evidence (WoE) analysis supports hazard and risk assessment while reducing animal testing by encouraging the integration of New Approach Methods (NAMs). A globally harmonized WoE framework, grounded in the key principles of OECD, can foster broader adoption of NAMs. This can be achieved by

establishing best practices for implementing the core principles of problem- formulation, collection of data, evaluation of evidence and weighing quality and relevance, and integrating lines of and reporting. In practice, these principles must be flexible to fit into regulatory contexts and to support integrating various data types. For example, when working with in vitro data, it is important to emphasize validity, reliability, and reproducibility, of the assay whereas integrating read-across data requires a focus on structural similarity, consistency, and concordance. Therefore, WoE as a conceptual framework can only be applied as 'fit-for-purpose'.

This case example applies a globally harmonized WoE framework to the human health evaluation of a metabolite of a pest management chemical and implementing a NAMs approach to avoid unnecessary animal testing. The methods of data collection included; Threshold of Toxicological Concern (TTC) approach with QSAR analysis for Cramer classification and structural alerts (OECD Toolbox; DEREK, and SARAH); identification of chemical analog(s) (RDKFingerprint and Tanimoto) for ID of structural analogs; comprehensive data on residues from field trials, and dietary exposure modeling (USEPA's DEEM).

The results of QSAR modeling and structural analogs indicated no alerts for genotoxicity, and the structure did not indicate potential for in vitro or ex vivo bioactivity. The metabolite was classified as Cramer Class III, with dietary exposure at < 1% of the TTC.

Based on the WoE, the metabolite was not included in the residue definition, and no additional animal testing was required. This case study illustrates the successful application of a WoE framework to a common regulatory scenario, providing a solid basis for safety assessment while promoting NAMs. It demonstrates how systematic evidence collection, evaluation, weighing and integration can inform decisions, minimize animal testing, and uphold scientific rigor in pesticide evaluations.

Disclaimer/Disclosure: Acknowledgements: IUPAC Task Group members, Project 2023-020-2-600 at: https://iupac.org/project/2023-020-2-600/

5.10.P-We146 Measuring and Assessing the Ecological Risk of Microplastics in Water and Sediments of Tokyo Bay

WATARU NAITO[1], Koji Ueda[1] and Yuichi Iwasaki[1] (1)National Institute of Advanced Industrial Science and Technology

Microplastic particles (MPs) are increasingly recognized as a potential risk to aquatic ecosystems; however, quantitative assessments linking environmental measurements to ecological risk remain limited. To address this gap, this study aims to measure the occurrence and characteristics of MPs in both water and sediments of Tokyo Bay and to assess their ecological risks based on these measurements. Field samples were collected from 36 stations in Tokyo Bay during 2023–2025, covering both surface water and surface sediments. MP concentrations, size distributions, morphologies, and polymer compositions were determined for particles in the 20–5000 μm size range. To account for smaller particles below the analytical detection limit, concentrations were extrapolated to the 1–5000 μm range assuming a continuous power-law size distribution. Particle volume, surface area, and mass were estimated from measured particle dimensions to enable comparisons across environmental compartments and exposure metrics. Measured and extrapolated MP concentrations in water and sediments were used to assess ecological risks. Risk characterization was performed by comparing

environmental concentrations with species sensitivity distribution (SSD)-based effect thresholds aligned to environmentally relevant particle characteristics. The assessment considered both pelagic and benthic exposure pathways, including ingestion-driven food dilution as a primary mode of action, with particle volume used as the main exposure metric. Surface area and mass were evaluated as complementary metrics to reflect different potential mechanisms such as surface interactions and particle uptake. Key sources of uncertainty were examined, including assumptions related to size-distribution extrapolation, analytical detection limits, and toxicity data selection. The influence of these uncertainties on risk estimates was evaluated to support transparent interpretation of results. Furthermore, potential future changes in ecological risk were explored by considering plausible scenarios of MP inputs and environmental processes. These exploratory analyses provide insight into how risk levels may evolve under different conditions and highlight the importance of long-term monitoring. This study demonstrates how environmental measurements of MPs in both water and sediments can be used to inform ecological risk assessment, providing a practical basis for evaluating microplastic risks in coastal ecosystems.

Disclaimer/Disclosure: This study was supported by the Long-range Research Initiative program of the Japan Chemical Industry Association.

5.10.P-We147 Risk Assessment of Accidental Emissions or Spills of a Manufacturing Plant in Canada

Bich-Lien Phan[1] and Jonathan Lalande[1] (1)Sanexen Environmental Services Inc.

Industrial facilities handling chemical products are subject to various regulatory requirements aimed at protecting both human health and the environment. Thus, such facilities seek to ensure that released chemical substances do not pose unacceptable toxicological or ecotoxicological risks in the case of accidental spills. To better understand and manage these risks, an assessment of potential accident scenarios and their consequences is essential.

This case study focuses on a manufacturing plant in Canada that handles various chemical products daily. Emergency plans have been developed for certain activities and equipment; however, few have been established for the chemical products handled. Thus, the study aims to assess the risk posed by accidental spills and identify critical substances and high-risk scenarios.

To do so, based on the current operations and activities, two plausible contamination pathways were considered in the event of an accidental spill of chemical products on-site. The first pathway consists of runoff into the stormwater drains and eventual discharge into the nearby river. The second consists of volatilization and evaporation into the ambient air.

The first step of the study consisted of identifying, from the list of chemical products that enter the plant annually and are considered toxic to the environment, the individual constituent substances and their respective quantities.

Based on the physicochemical properties (density, vapour pressure, etc.) and quantities of the different substances, the maximum concentration of each chemical substance potentially reaching stormwater drains was

calculated. In parallel, the volatilization rate of each chemical substance was calculated and used to estimate ambient air concentrations with a screening model (AERSCEEN), following their potential on-site volatilization.

The third step involved documenting aquatic toxicity values and human inhalation toxicity reference values for each individual substance, which were then used to characterize the risks associated with the estimated concentrations in water and ambient air, respectively.

This approach enabled the prioritization of substances and scenarios with the highest potential for adverse environmental impacts, allowing the site owner to identify and implement targeted mitigation measures to protect the environment.

5.10.P-We148 The Plan of Priorities: Substances Prioritized for Assessment Under the Canadian Environmental Protection Act, 1999

Katrina Sullivan[1], Christopher Fraser[1], Marisol Eggleton[1] and Magdalena Jagla[1] (1)Environment and Climate Change Canada (ECCC)

As per recent amendments to the Canadian Environmental Protection Act, 1999 (CEPA), the Government of Canada is required to develop, consult and publish a Plan of Priorities (the Plan) that describes planned activities for addressing substances in Canada to protect the health of people in Canada and the environment. The Plan outlines the substances prioritized for assessment and other activities to assess, control, or manage the risks to the environment or human health, as well as activities that promote the development and incorporation of alternative methods and strategies to replace, reduce or refine vertebrate animal testing. A proposed Plan was published for public consultation in October 2024 and comments helped to refine the Plan of Priorities, which was published in July 2025. The listing of individual substances and substance groupings proposed as priorities for assessment is provided together with corresponding rationales. Ecotoxicological considerations for the assessments of the following groups of substances are highlighted: N-(1,3-dimethylbutyl)-N′-phenyl-p-phenylenediamine (6PPD) and related p-phenylenediamines (PPDs), bisphenols, fluoropolymers and organic flame retardants.

5.10.P-We149 A Proposed Bat Ecological Risk Assessment Framework and Exposure Model

George Huddleston[1] and Jenna Molaro[1] (1)Copperhead Environmental Consulting Inc.

Current ecological risk assessment (ERA) methods fail to adequately address risks to bats, highlighting a critical data gap in wildlife risk assessment. While exposure models exist for other mammals, birds, reptiles, and amphibians, bats remain excluded despite occupying a unique and critical ecological niche. This poster presents a novel bat-specific ERA framework and exposure model designed for integration into state and federal protocols. Key components include: (1) Assessment Endpoints—identifying bat population metrics vulnerable to contaminant exposure; (2) Analysis—assessing exposure pathways, defining exposure factors, evaluating potential adverse effects, and identifying ecotoxicity benchmarks; and (3) Risk Characterization—integrating exposure and effects data to estimate risks using real-world contamination levels to validate and refine the model. Given the immense ecological and economic value of bats, implementing standardized risk assessment

methods is essential for the protection and conservation of bat populations.

5.10.P-We150 Optimizing an Environmental Fate and Effect Testing Program for New Photoacid Generators Under the Toxic Substances Control Act

Tim Verslycke[1] and Jessie Kneeland[1] (1)Gradient

In the United States (US), the Environmental Protection Agency (US EPA) completes extensive risk assessments of new chemicals within the Pre-Manufacture Notice (PMN) process under the Toxic Substances Control Act (TSCA). Photoacid generators (PAGs) are a group of specialty chemicals used in the semiconductor industry that US EPA is assessing using a category approach. Though PAGs are used at low volumes in controlled environments, concerns about potential persistence, bioaccumulation, and toxicity (PBT) properties have prompted US EPA to request data for an extensive list of environmental fate and effect endpoints. PAG manufacturers have formed a consortium to collaboratively generate the test data requested by US EPA.

This presentation will outline how the PAGs Consortium has relied on read-across, exposure, and test design considerations, to try to streamline the testing program for environmental fate and effect data. For example, some environmental fate tests were waived by using read-across to structurally similar analog chemicals with adequate data or based on modeling results showing no expected degradation by a particular pathway, such as hydrolysis. Bioaccumulation is a key endpoint for assessing environmental hazard as well as human health exposure. Until data for the category are sufficient to predict bioaccumulation on the basis of chemical structure and/or physicochemical properties, such as octanol-water partitioning, some fish bioaccumulation testing is needed; however, potential refinements to the standard test design can be made to reduce the use of vertebrate animals, consistent the 3Rs (Replace, Reduce, Refine) principles. For aquatic toxicity testing, chronic studies are proposed to support the evaluation of both acute and chronic exposures. Further, limit-test designs are being considered to help minimize the number of test organisms needed and streamline data generation. All of these refinements to the testing program are being developed collaboratively between US EPA and the regulated industry to optimize testing without compromising the quality of environmental hazard and risk assessment.

5.10.P-We151 Risk Assessment of Eze River Water in Ugwueke, Abia State, Nigeria: Efficacy of Low-Cost Zeolite-Clay Filters for Microbial and Physicochemical Remediation

NOSIRI CHIDI[1], NWAOGWUGWU JOEL[2], IGWE JUDE[3] and IGWE JOY[4] (1)Department of Pharmacology/Toxicology, Faculty of Pharmaceutical Sciences, Abia State University, Uturu, Nigeria, (2)Department of Biochemistry, Faculty of Biological Sciences, Abia State University, Uturu, Nigeria, (3)Department of Chemistry, Faculty of Physical Sciences, Asia State University, Uturu, Nigeria, (4)Department of Pharmaceutical Microbiology/Biotechnology, Faculty of Pharmaceutical Sciences, Abia State University, Uturu, Nigeria

Access to safe drinking water remains a critical environmental and public health challenge in rural Nigeria, where surface waters face increasing exposure to anthropogenic stressors.This study assessed the physicochemical and microbial quality of Eze River in Ugwueke, Bende Local Government Area of Abia State, Nigeria and evaluated the remediation efficacy of a low-cost clay candle filter impregnated with zeolite for exposure reduction. They lack access to potable water and therefore depend heavily on Eze River, which cuts

across the autonomous communities of the Ugwueke Ibinaeze Ancient Kingdom hence serve as a major water source for the populace. Water samples were collected from selected points along the river and analyzed using standard laboratory procedures. Parameters examined included pH, turbidity, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), and Total Viable Count (TVC) of Microbial Load. To evaluate purification efficiency, untreated water samples were filtered using a zeolite-impregnated clay candle filter, and the results were compared with World Health Organization (WHO) and Nigerian Standard for Drinking Water Quality (NSDWQ) limits. Untreated river water exhibited elevated turbidity, EC, TDS, hardness, and microbial load, consistent with contamination from domestic activities, agricultural runoff, and poor sanitation. Filtration significantly reduced EC from 110.50±0.98 to 91.53±0.15 µS/cm, TDS from 77.73±0.84 to 66.00±1.42 mg/L, turbidity from 173.10±1.10 to 81.1±0.09 NTU, TH from 21.63±1.02 to 0.00±0.00 mg/L, and TVC from 2.25±0.15 to 0.26±0.02 CFU/mL. A slight pH increase from 8.26±0.16 to 8.73±0.04 was observed, likely due to mineral constituents of the filter matrix. The findings showed that zeolite-clay filtration effectively reduced physicochemical and microbial contaminants, thereby lowering health risks associated with the use of Eze River water. This affordable and locally adaptable technology provides a sustainable option for decentralized water treatment in resource-constrained communities. The study also provides valuable data for risk-based water management and supports sustainable environmental health interventions in vulnerable areas.

Disclaimer/Disclosure: This work is self sponsored

5.10.P-We152 Targeted Survey of Cyanotoxins From Benthic Isolates and Natural Samples Around the United States Part 2: More Cool Stuff!

Avery Tatters[1] and Stuart Oehrle[2] (1)University of Washington, Olympic Natural Resources Center, (2)Northern Kentucky University (NKU)-Waters Lab

Benthic blooms have been the source of episodic toxic events throughout the world, including across the United States. Animal mortalities in particular have been instrumental in highlighting the importance of better understanding these naturally occurring scenarios and corresponding metabolites. Targeted monitoring using Liquid Chromatography/Tandem-Mass Spectrometry (LC/MS/MS) is commonly used to monitor a wide variety of compounds in differing matrices. Using a previously developed multi-toxin method that has expanded to include over 30 additional microcystins, variants of anatoxin and cylindrospermopsin as well as several dermatoxins, other cyanobacterial metabolites, euglenopyhycin, and notable marine toxins, we examined samples and isolates from around the United States. Although we will present results across many of the 12 level 1 ecoregions of the country, the focus will be on material originating from lands of Coastal Treaty Tribes along the outer Washington Coast (Olympic Peninsula). This talk will cover several examples of toxin analysis of waters from a variety of locations to show how you can “see” (detect) additional compounds and how you can “search” for others with some basic knowledge by using backward (precursor) monitoring. This can provide a useful screening tool for the detection of any unusual toxins. We will show examples of the usefulness of additional toxin screening for benthic sample analysis from a wide variety of rivers, lakes, streams, and ponds from around the United States.

5.10.P-We153 Mechanistic Influence of Different Organic and Inorganic Sorbents and

Their Surface Chemistry on the Retention of per- and Polyfluoroalkyl Substances

Mayda Rojnik[1] and Barbora Böserle Hudcová[2] (1)Czech University of Life Sciences Prague, (2)Czech University of Life Sciences, Prague

Per- and polyfluoroalkyl substances (PFAS) are persistent contaminants whose mobility, leaching behaviour, and remediation are controlled by solid surface interactions. Their high mobility potential in different environmental matrices leads to bioaccumulation across trophic food chains and poses significant environmental and human health threats. Consequently, investigating and designing remediation techniques that do not fail to trap these “forever chemicals” is vital. Functional chemistry groups, surface charge, chain length, and solution chemistry all affect PFAS sorption. Thus, using various organic and inorganic sorbents, carbon nanotubes, biochars, layered double hydroxides (LDH), birnessite, kaolinite, and goethite, this study investigates the retention of six different anionic PFAS: perfluorooctanoic acid (PFOA), perfluorooctanesulfonate (PFOS), perfluorobutyric acid (PFBA), perfluorobutanesulfonate (PFBS), perfluorohexanoic acid (PFHxA), and perfluorohexanesulfonate (PFHxS). To assess surface affinities of sorbents, 24 h batch equilibrium experiments were conducted using a standardised 1 g/L solid-to-liquid ratio. An aqueous suspension of sorbents was spiked with the target PFAS at an initial concentration of 50 ppb (µg/L). Following rotary shaking, suspensions were filtered using 0.22 µm polypropylene filters. The residual PFAS concentrations were analysed using liquid chromatography-tandem mass spectrometry (LC-MS/MS). These batch experiments were also monitored for changes in the pH of the solutions, alongside container wall retention of PFAS. Overall, these initial batch experiments demonstrate that organic sorbents, particularly those carbon-based, carbon nanotubes and high-temperature wood biochar, exhibit the highest removal efficiencies. Conversely, due to the electrostatic repulsions driven by alkaline pH shifts, mineral phase sorbents were mostly ineffective. To expand on these findings, upcoming batch experiments will include engineered composites, amorphous manganese oxide, ferrihydrite and a biochar-LDH. These initial batch experiments are critical pre-tests for broader future research, where PFAS will be modelled within a multi-pollutant soil matrix to determine the most efficient amendments for this complex contamination. Compared to conventional remediation methods, these sustainable organic materials offer a more environmentally friendly alternative for in situ remediation of various environmental compartments.

Disclaimer/Disclosure: This research was supported by the Internal Grant Agency of the Faculty of Environmental Sciences, Czech University of Life Sciences Prague (project no. 2026B0023) under the project title "Reactive Surfaces and The Soil Properties Control PFAS Fate and Ecotoxicity: A Combined Mechanistic Analysis" .

7. Policy, Management and Communication

Bridging Science and Public Understanding: Communicating Environmental Contaminant Risks

7.02.T-01 Helping the Public Understand per- and Polyfluorinated Substances (PFAS): Risks, Exposure, and Practical Actions

Charles Powley[1] (1)STRIDE Center for PFAS Solutions

Explaining environmental contamination risks to the general public can be difficult. Effective communication should improve understanding without creating confusion, unnecessary fear, or panic. Per- and polyfluoroalkyl substances (PFAS) are especially challenging to discuss because they include a large number of compounds, many of which are still not well characterized in terms of composition, exposure, and toxicity. In my experience, people are often most concerned about hazards they cannot see, such as PFAS at ng/L concentrations, but they also want practical guidance on what they can do.

A useful approach is to simplify the science and present only the most essential information. Chemical structures and graphs should be limited and easy to interpret, and tables should include only the minimum number of entries needed to support the message. As with any presentation, readability is critical. When introducing PFAS, I begin with a simple explanation of the chemistry, followed by a brief history of how these substances were developed and used. I then introduce an intentionally simplified risk framework:

Risk = Toxicity × Exposure

After introducing the risk concept, I explain the steps people can take to reduce their exposure. Examples include:

- using home water filters,
- choosing PFAS-free cookware, and
- selecting PFAS-free clothing and other consumer products.

The toxicity term is typically based on mammalian toxicology studies, and people often assume that it cannot be changed at the individual level. However, individuals may be able to reduce the health impacts of PFAS and other environmental contaminants by adopting healthier lifestyle habits, such as quitting smoking and eating a diet rich in antioxidants. This potential to reduce overall harm is often overlooked.

7.02.T-02 Environmental Risk Assessment as a Decision Support Tool: Balancing Scientific Rigor and Practical Risk Management

Francis Ramacciotti[1] and William Schew[1] (1)GHD

Environmental risk assessment (ERA) is a critical framework for evaluating potential human health and ecological impacts associated with chemical releases to the environment. When applied appropriately, ERA

provides a scientifically defensible basis for prioritizing concerns, informing risk management decisions, and allocating resources efficiently. However, risk assessments are often perceived as lacking transparency or overly conservative, which can lead to misinterpretation of results and risk management actions that are disproportionate to actual site conditions.

This presentation examines the role of environmental risk assessment as a decision support tool, with emphasis on aligning assessment complexity with site specific objectives and data quality. Key elements of the ERA process are discussed, including development of conceptual site models, screening level evaluations, refined exposure and toxicity assessments, and uncertainty analysis. Common pitfalls—such as inappropriate use of screening criteria as cleanup targets, failure to contextualize conservative assumptions, and insufficient communication of uncertainty—are highlighted through illustrative case examples.

The discussion emphasizes best practices for integrating human health and ecological risk assessment into regulatory and stakeholder decision making, particularly for contaminated sites and emerging contaminants. By focusing on transparency, proportionality, and clear communication of assumptions and limitations, environmental risk assessments can move beyond compliance exercises to become effective tools for protecting human health and the environment while supporting sustainable and practical risk management outcomes.

7.02.T-03 From Passive Samplers to Public Engagement: Communicating Polycyclic Aromatic Hydrocarbon Patterns in Charleston Harbor

Maggie Knight[1], Cheryl Carmack-Smith[2], Emily Pisarski[3], Ed Wirth[4], Andrew Wunderley[2] and Marie DeLorenzo[5] (1)Research Planning Inc (RPI), (2)Charleston Waterkeeper, (3)National Centers for Coastal Ocean Science (NCCOS), (4)No Affiliation, (5)National Oceanic and Atmospheric Administration (NOAA)

Developing coastal environments are vulnerable to contamination from human activities, particularly in flood-prone regions with complex hydrology. In Charleston, SC, waterways support recreation, fisheries, shipping, defense, agriculture, and tourism, making clear communication of environmental risks essential for ecosystem and community health. A key challenge is translating contaminant monitoring data into accessible information for diverse audiences. Polycyclic aromatic hydrocarbons (PAHs); are persistent contaminants and indicators of urban runoff that provide insight into human impacts on coastal systems. This project assessed spatial patterns of PAHs in estuarine waterways and developed an environmental risk communication tool. To support monitoring and community engagement, we partnered with Charleston Waterkeeper (CW), a local nonprofit. Silicone band passive samplers were deployed quarterly beginning in Fall 2021 at 20 estuarine sites within the Charleston Harbor watershed (CHW). Sites were originally selected by CW for bacterial monitoring based on recreational use and community relevance. Passive samplers were used to integrate contaminant concentrations across tidal and precipitation conditions. PAHs were quantified using gas chromatography tandem mass spectrometry, and total PAH concentrations were mapped to identify spatial trends. Findings were translated into an interactive ArcGIS StoryMap integrating graphical and text-based narratives to improve accessibility of results along with environmental context in order to enhance stakeholder understanding of potential contaminant exposure in a highly utilized watershed. Results indicate that PAHs are present throughout this estuary system, with higher concentrations in areas influenced by boat and vehicle traffic, dense development, and mismanaged septic systems. Several hotspots align with areas previously designated as impaired through

CW bacterial monitoring. Detected concentrations did not exceed drinking water guidelines, but did indicate ongoing pollutant inputs within the CHW. The StoryMap has received more than 400 views, and related outreach through CW and NOAA communication channels reached thousands through social media and email campaigns. This project demonstrates that combining passive sampling, nonprofit partnerships, and geospatial storytelling can characterize contaminant patterns while supporting environmental risk communication and community engagement in coastal systems.

7.02.T-04 From Survey Data to Public Outreach: Leveraging Angler Input for Effective Risk Communication at a Mercury Superfund Site (Lavaca Bay, Texas)

Jessica Dutton[1] (1)Texas State University

The Alcoa Point Comfort Operations Plant (Texas, USA) refined bauxite from 1958 to 2016. In the 1960s and 70s, wastewater from the chlor-alkali production plant on the site released mercury (Hg) into the bay next to the facility, contaminating the water, sediment, and biota. The site was added to the U.S. EPA National Priorities List in 1994 and is undergoing long-term environmental monitoring and remediation. Due to high Hg concentrations, the Alcoa (Point Comfort)/Lavaca Bay Superfund site has been closed to the retention of fishes and blue crab since 1988; however, catch and release fishing is allowed. Recreational anglers fishing along a 0.9 mile long old road next to the Superfund site are frequently seen keeping their catch, even though there are three signs informing of the retention ban where the old road meets the highway. To understand why some anglers retained their catch, between August 2024 and July 2025, 100 anglers were surveyed about their fishing activities in the Superfund site. Questions focused on what species they caught, whether they retained their catch, and if so, did they consume it. The Hg issue was then discussed with each participant, and if they were consuming their catch, they were educated about the risks of Hg exposure from consumption of seafood caught at this site. The most commonly caught species were hardhead catfish (Ariopsis felis), gafftopsail catfish (Bagre marinus), red drum (Sciaenops ocellatus), and black drum (Pogonias cromis). 46% of participants responded that they do catch and release but will also sometimes keep their catch if it's within the size limits, and 4% responded they only keep their catch. Of the 50% of participants that keep their catch, red drum, black drum, and striped mullet (Mugil cephalus) were retained the most. While striped mullet was primarily used as bait, red drum and black drum were consumed. When asked about why they consumed their catch when there was a retention ban, the most frequent response was they did not know the area where they were fishing was under the ban because they were at least 0.25 miles away from the signs. After discussing the results of this study with Alcoa, the company installed two new signs in the bay next to the road in late 2025. This study demonstrates that surveys can successfully be used to understand an angler's knowledge about a public health issue and industry can use that information to better inform the public about seafood contamination risks.

7.02.T-05 Found, Feared, and Amplified: The Risk-Characterisation Gap in Microplastics Health Science

Frédérique Duplain-Laferrière[1] (1)Tactix Government Relations & Public Affairs

Communicating environmental contaminant risks depends on a chain running from scientific detection through risk characterisation to public understanding. When that chain breaks, detection findings reach the public stripped of the context needed to judge whether a detected substance poses a meaningful risk. Micro- and

nanoplastics (MNP) in the human body offer a revealing case study: particles are now widely reported in human blood, placenta, and tissues, these findings attract intense media coverage, yet the toxicological thresholds needed to interpret them barely exist.

Using structured literature reviews, AI-assisted classification, and social-listening analysis, we traced this chain across four linked layers: how MNP detection studies frame health, what the supporting health-effects literature shows, which findings reach the public, and how North American consumers and policymakers perceive them.

Of 163 primary MNP detection studies in human matrices, the large majority asserts health relevance, yet only a small fraction (under one in ten) performs quantitative risk characterisation, relying instead on association or implication. The supporting health-effects literature (489 studies) is dominated by experimental rodent work, of which the great majority demonstrate effects only at doses far above realistic human exposure; direct human effect evidence is sparse and largely observational. Media attention concentrates on association and bare-detection studies, while rigorous risk characterisation accounts for a negligible share of media attention. Finally, social-listening analysis of North American online discourse indicates that public perception mirrors this framing: health risks from MNPs are perceived as near-universal and largely settled, while confidence in regulatory institutions remains low, a pattern reflected, not attenuated, in policymaker discourse. Full results will be presented.

These findings locate where the science-to-public chain breaks: health relevance is asserted far faster than the evidence base can support it, echoed by media and reflected in public discourse. The approach generalises to other contaminants of public concern, offering a diagnostic tool to help researchers, regulators, and industry jointly pinpoint where risk communication fails and rebuild public trust on proportionate evidence

Bridging Science and Public Understanding: Communicating Environmental Contaminant Risks

7.02.P-Th206 Communicating Urban Fish Contaminant Risks Through Watershed Partnerships and Public Engagement

Sabine Malik[1], Jorge Bogantes Montero[2] and Lance Yonkos[1] (1)University of Maryland, (2)Anacostia Watershed Society

Environmental contaminant research is often generated through highly technical methods, yet its public value depends on whether affected communities can understand, trust, and use the information. Further, field research for this purpose is often obscured from public view until Natural Resource Damage Assessments or other remediation strategies are complete, despite engaging regularly with the system in question. This is an especially important issue in urban watersheds such as the Anacostia River, where legacy contamination, fish consumption advisories, recreational use, ecological restoration, and environmental justice concerns intersect. Many in the public view the Anacostia River is as a polluted wasteland beyond redemption, though there are also many communities that subsistence fish in the river. Through partnership with the Anacostia Watershed Society, I have worked to translate fish health and contaminant research into public-facing communication through boat tours, community tabling events, fish consumption advisory outreach, stakeholder conversations,

and informal education about ongoing research in the watershed. Ultimately, I found that the role of messenger identity cannot be ignored in environmental risk communication. Scientists entering community spaces may not always resemble, represent, or share the lived experience of the audiences they hope to reach. In the context of fish consumption advisories and urban contaminant exposure, this makes humility, partnership, and trust-building essential components of effective science communication. Additionally, local organizations typically have recurring events and existing partnerships that present far easier opportunities for science communication than the creation of new activities. This also creates continuity if materials can be preserved and provided to the organizer so that they can be presented by others even after I am no longer involved. Finally, relationships with these organizations can also be particularly helpful for research occurring out of universities, as it provides a mutual benefit for student opportunities and education.

7.02.P-Th207 Long-Term Study of Fecal Coliform Contamination, Source Tracking, and Public Outreach of the Rappahannock River

Hannah Reents[1], Garrett Driscoll[1], Sofia Di Bengino[1], Lynn Lewis[1], Lisa Wu[2] and Tyler Frankel[1] (1)University of Mary Washington, (2)Potomac River Keeper Network

Total coliforms are a broad group of bacteria commonly found in vegetation, soil, and warm-blooded animal intestinal tracts that can be used as a water sanitary indicator. Fecal coliforms are a specific subgroup of coliform bacteria found solely in the intestinal tracts of warm-blooded organisms that are strongly correlated with gastrointestinal illnesses and other health effects on both humans and wildlife. Sources of contamination include wastewater treatment plant overflows, leaking septic systems, agricultural runoff, and wildlife or pet waste. While the Rappahannock River is commonly utilized for recreational activities, few studies have been conducted to examine the presence, concentrations, potential sources, and long-term patterns of coliform contamination in commonly utilized areas. As such, this study was designed to 1) generate baseline data to track contamination levels in correlation with rainfall, temperature, and seasonality, and 2) provide the public with easily accessible information regarding the cleanliness of recreational areas. Surface water samples were collected weekly from five locations along the Rappahannock River with dissolved oxygen (DO), pH, temperature, total dissolved solids, and salinity measurements taken. Total and fecal coliform concentrations were quantified using the IDEXX Colilert-18/ Quantitray 2000 system. Samples were incubated at 35°C for 18-22 hours, after which total and fecal coliform most probable number (MPN) values were measured under UV light using an IDEXX 2000 MPN Table. Results were then released to the Potomac Riverkeeper Network Swim Guide, the Chesapeake Monitoring Cooperative Data Explorer website, and social media posts by the Rappahannock Group Sierra Club for public access. Several sites exceeded the EPA single sample maximum contaminant limit of 410 MPN/100 mL during the summer season, with precipitation having a positive correlation with fecal coliform increases. A negative correlation was found between DO levels and coliform levels due to increased bacterial respiration. A polymerase chain reaction (PCR) was performed to identify bacterial DNA from human, cattle, waterfowl, and dog sources within the river collections. These results provide opportunities for future research into mitigation strategies. Collectively, the results of this study will help to better inform the public, create a reliable dataset for future research, and identify sources of significant contaminators.

7.02.P-Th208 Use of Seafood Consumption Surveys To Infer Potential Mercury Exposure

in Recreational Anglers Within the Matagorda Bay System (Texas, USA)

Lacey Parker[1], Joseph Kuntz[1] and Jessica Dutton[1] (1)Texas State University

The Matagorda Bay system is home to several important fisheries, including Red Drum (Sciaenops ocellatus), Black Drum (Pogonias cromis), Spotted Seatrout (Cynoscion nebulosus), and Southern Flounder (Paralichthys lethostigma). Due to its proximity to the Gulf of Mexico, offshore recreational fishing is also a popular pastime, targeting species like Red Snapper (Lutjanus campechanus), King Mackerel (Scomberomorus cavalla), and Mahi-Mahi (Coryphaena hippurus). No prior studies have investigated recreational angler seafood consumption patterns within this bay system, which is critical to understanding potential mercury (Hg) exposure risk, since this is the primary pathway of Hg exposure for humans. Using surveys, we examined the seafood consumption patterns of recreational anglers in four locations within the Matagorda Bay system (Port Lavaca, Palacios, Matagorda, and Port O'Connor; n = 150 per location). Respondents were asked where they got their seafood from, which months they consumed the most and least seafood, what species they ate, and how frequently they consumed them. 73% of anglers surveyed in Port Lavaca and Palacios obtain their seafood from stores or restaurants, while anglers surveyed in Matagorda and Port O'Connor primarily consumed self-caught seafood (89% and 94% of participants, respectively). This is most likely due to more anglers in Port Lavaca and Palacios releasing their catch, whereas more anglers in Matagorda and Port O'Connor retained what they caught. Anglers' seafood consumption was highest in the summer months and lowest in the winter months. For bay species, Red Drum, Black Drum, Spotted Seatrout, and Southern Flounder were consumed the most, while the predominant offshore species consumed were Red Snapper, Mahi-Mahi, and Yellowfin Tuna (Thunnus albacares). All these species have a mean Hg concentration ranging between 0.150 and 0.350 µg/g wet weight. In comparison, high Hg species (> 1 µg/g), including Blue Marlin (Makaira nigricans), King Mackerel, Swordfish (Xiphias gladius), and Golden Tilefish (Lopholatilus chamaeleonticeps) were only consumed, on average, once per year. These findings help to understand seafood consumption patterns and the potential likelihood of Hg exposure to recreational anglers within the Matagorda Bay system. These results will be used to effectively communicate Hg exposure risks to seafood consumers.

Can I Trust Your Data? Data Quality Issues in Modern Ecotoxicology

7.03.T-01 When Monitoring Fails To Inform: Challenges in Translating Pesticide Water Quality Data To Meet Public Policy Goals

Katie Murray[1], Kim Anderson[2] and Isabella Nelson[2] (1)Oregonians for Food & Shelter, (2)Oregon State University

Regulatory programs focused on water quality require the application and translation of complex science, and communication with non-scientific audiences, in order to support meaningful improvements. Oregon is home to a unique regulatory program, the Pesticide Stewardship Partnership (PSP), which seeks to protect water quality through partnerships with industry and voluntary stewardship. The PSP operates through a targeted water quality monitoring program that samples streams adjacent to a variety of land uses, including urban, agricultural, and forestry. Findings are communicated to stakeholders, some of whom have obtained funding from the program to build local partnerships, implement targeted education, and effect change. Historically, the PSP program has achieved notable success by focusing on effective Best Management Practices tailored to specific watersheds, pesticide uses, and local communities. As the program has evolved, questions have

emerged regarding aspects of data analysis and interpretation that may influence how monitoring results are translated into management practices. For example, aquatic risk assessments rely on benchmarks that may not fully align with the specific exposure scenarios represented by the monitoring data. In addition, interpretation frameworks emphasizing maximum detected concentrations may disproportionately weight infrequent detections, while exclusion of low-concentration observations can influence summary statistics. Consideration has also been given to how samples that do not fully meet quality control criteria are incorporated into analysis and communications. Furthermore, use of detection frequencies to compare locations or pesticides may be difficult to interpret within a monitoring framework intentionally designed to target areas expected to have elevated detections. Collectively, these methodological considerations may affect prioritization efforts, stakeholder communications, and the overall effectiveness of the program implementation. Accurate application and communication of rigorously conducted science are essential for ensuring effective regulatory decision-making and sustained water quality improvements. This work highlights several challenges associated with interpreting monitoring data from Oregon's PSP Program and provides recommendations for improving analytical approaches and program outcomes based on a re-analysis of more than 10 years of water quality monitoring data from two watershed basins.

7.03.T-02 Data Quality Issues in Deriving Environmental Quality Standards Under the European Water Framework Directive: A Growing Culture of Misuse and Mistrust?

Iain Wilson[1], Graham Merrington[1] and Dean Leverett[1] (1)wca environment Ltd.

The Water Framework Directive (WFD) is a unifying piece of legislation that brings together existing national and European commitments on water resources and water quality. One of the tools to be used to meet these legal commitments are Environmental Quality Standards (EQS) derived for chemicals that are deemed to present a European-wide risk to surface waters. These EQS are 'limits' above which a chemical is considered to present potential aquatic risk. In Europe the derivation of these quality standards, which are legally binding, regulatory 'bright-lines', enshrined in national legislation, is performed by the European Commission's technical contractors, and by individual member state (country) regulators, with very limited stakeholder influence or input.

Protocols have been published detailing the scientific derivation process to be followed, and schemes to evaluate the reliability and relevance of effects and exposure data are readily available (e.g. CRED (Criteria for Reporting and Evaluating ecotoxicity Data) and CREED (Criteria for Reporting and Evaluating Exposure Datasets)). European-wide EQS are derived by considering both effects (ecotoxicity) and exposure (measured chemical concentrations in the environment) data. However, in the most recent round of EQS derivations and substance prioritisations performed clear challenges in regulatory trust have emerged, including:

- The dismissing of reliable and relevant effects and exposure data, especially those provided by stakeholders (data from studies funded by industry are considered "biased");
- Misuse (or non use) of data to reach a specific outcome (numerical value);
- The lack of provision of all data used in the derivations, meaning it is not possible to review or repeat assessments or verify findings.

A scientific process that is not transparent or consistent engenders mistrust and scepticism and is unlikely to lead to robust or relevant environmental outcomes. In this presentation we will attempt to identify the triggers for this recent culture shift, and flag what we believe to be the ongoing contributory factors perpetuating this misuse and mistrust and ultimately the resulting suboptimal environmental outcomes. We will also recommend

steps to be taken to increase trust in scientific data generation in regulatory processes, and how we can ensure its effective and transparent use to inform regulatory and governmental decisionmakers.

7.03.T-04 Where's the Analytical? Why Analytical Verification of Exposure Is Important in Ecotoxicology Studies

Alan Jones[1] (1)BASF Agricultural Solutions

Can we trust the data? Most SETAC attendees want their scientific output to be accepted and used in some context to improve environmental outcomes. To meet this objective, it is imperative that scientists produce high quality, reproducible data. Robust analytical verification of exposure concentrations is critical to producing high quality ecotoxicological studies. Unfortunately, many otherwise excellent studies with potentially interesting results are disregarded by the regulatory community when analytical data, which are used to confirm results and inform the conclusions of the study, are limited, questionable, or not reported. It is not a matter of trust on the part of decision-makers. Rather, decision-makers can't rely on results and conclusions that lack this fundamental element of a good experimental design. This presentation will provide examples from the literature of quality analytical reporting, identify some pitfalls to avoid, and make suggestions for cost-effective analysis techniques and sampling approaches that don't exhaust an entire research budget.

7.03.T-05 Recommended Minimum Reporting Information for Publication of Ecotranscriptomics Studies

Alexander Cole[1], Camille Baettig[2] and Laura Langan[3] (1)No Affiliation, (2)U.S. Environmental Protection Agency (US EPA), (3)University of South Carolina

In 2025, a systematic literature review examining trends and limitations in the reporting of aquatic toxicology experiments examining transcriptomic endpoints according to the OECD -omics reporting framework (OORF) revealed inconsistencies that greatly affect the reproducibility of the data. Although it is largely accepted by the scientific community that the transparent reporting of experimental variables increases confidence, reuse, and impact of results, consensus has not resulted in action. While many journals have adopted the requirement to provide a data availability statement or data transparency policy, these policies do not completely prevent insufficient reporting. Concerted effort among researchers, sequencing partners, and journals is necessary to set a precedent.

SETAC has consistently advocated for both open data – data that are accessible and reusable for reanalysis or metanalysis without additional context – and open science in general. A technical issue paper (TIP) was released by SETAC in January of 2026, which outlines the recommended minimum reporting information for publication of ecotranscriptomics studies. These recommendations were the result of an international, multidisciplinary effort that included working group members from academia, government, and industry such as sequencing partners. This presentation will provide detail into the recommendations outlined in the publication and discuss next steps in harmonizing data reporting to enhance confidence in published data, advance NAMs, increase cross-comparability, and improve animal welfare.

7.03.T-06 Checklist-Based Quality Criteria for Generating and Reporting Acute Fish Cell

Line Data in the FACT Database

Marion Revel[1], Christoph Schür[1], Melanie Fischer[1], Christopher Faßbender[2], Gilly Stoddart[2] and Kristin Schirmer[1] (1)Swiss Federal Institute of Aquatic Science and Technology (Eawag), (2)PETA Science Consortium International e.V.

The RTgill-W1 fish cell line assay, a bioassay that is validated and standardized as the OECD Test Guideline (TG) 249, has shown great promise as an alternative method to fish acute toxicity testing (e.g., OECD TG 203). Despite its rigorous validation and adoption as ISO standard 21115 and OECD TG 249, its uptake is facing barriers such as reluctance in regulatory acceptance, often due to a lack of understanding and confidence in using the data, and some data not being publicly available. This could be helped by a comprehensive characterization of the assay's applicability domain, i.e., the chemical space in which the assay can be expected to perform reliably, which, however, requires an overview of all available data.
To collect all available fish cell acute toxicity data, we created the Fish Acute Cell Toxicity (FACT) database as a continuously updated resource. Currently, the FACTdb contains toxicity (cell viability) data on over 100 chemicals represented through EC50, EC10, and non-toxic concentrations (NtC) values, calculated using a consistent analysis workflow. In the process of data curation, it became evident that even with such a standardized assay, there is still variation in how the assay is conducted and the data is reported. This often leaves questions regarding the validity and suitability of the data for inclusion into the database. Accordingly, we created checklist-based quality criteria that sensitize users towards key elements of data generation and reporting. This checklist follows the OECD guidance document 147 requirements "on the Generation, Reporting and Use of Research Data for Regulatory Assessments". It therefore requires information across the categories of chemical properties, experimental setup, and validity criteria. The checklist serves as a quality assessment before data are entered into the FACT database. It assigns guideline adherence levels from 1 to 3: Level 1 indicates full compliance with OECD TG 249, Level 2 reflects adherence with some deviations (e.g., alternative plate formats), and Level 3 concerns relevant research data (e.g., other fish cell lines).
We aspire for the combination of the checklist and FACT database to strengthen both the confidence of the regulatory community in how to best conduct the assay, improve the reporting quality of generated data, motivate further uptake of the assay, and help towards higher regulatory acceptance by further characterization of the evolving applicability domain.

Can I Trust Your Data? Data Quality Issues in Modern Ecotoxicology

7.03.P-We084 The MAGIC Effect Graph – an Ecotoxicological Knowledge Base

Lara L. Petschick[1] and Jakob Wolfram[1] (1)RPTU University Kaiserslautern-Landau

Laboratory effect data are needed to assess environmental risks of chemicals. Databases (db), such as the US EPA ECOTOX Knowledgebase and the EFSA OpenFoodTox, collect and provide these data to the public. Modern approaches like machine learning (ML) can unlock these data to assess the potential environmental impact of the large, increasing number of manufactured chemicals, but they rely on a high data quality for robust results. For the MAGIC effect graph, we compiled six large effect dbs with different scopes (including standardized and non-standardized tests) into a single graph db (668k endpoints, 10k chemicals, 10k biological taxa) by harmonizing terminologies and deriving quality indicators based on study parameters and curation status. Data is enriched by connecting it to additional sources (e.g., the GBIF Backbone Taxonomy) and by

applying ML to predict missing labels (i.e., acute, chronic). As a result, the MAGIC effect graph provides the following solutions:
1.It offers a harmonized view over six of the most important dbs for laboratory effect data. With the MAGIC effect graph, all these dbs can be queried simultaneously.
2.Additional curation of the underlying data allows for consolidation of the ecotoxicological knowledge in the source dbs. By synchronizing the terminologies of the source db, it is for the first time possible to get an overview over the available effect data without overlaps that may bias the results.
3.A normalized score (0-1) aggregates essential quality indicators to help interpret and select reported effect endpoints, e.g., in situation where different effect concentrations are reported.
We demonstrate the usefulness of the score by benchmarking four hypothetical endpoint selection scenarios (S1-4) with original, curated study results from two large-scale studies in Germany and the US, respectively. In S1 the minimum effect concentration of all available was selected, in S2 the effect concentration with the highest score, in S3 a randomly selected effect concentration, and in S4 the median effect concentration among those above a fixed score. Applying S1-4, the analysis of the two case studies was recreated and checked whether the original interpretations still hold true. Our results show that scenarios using the score generally outperform others in reenacting original results, indicating the score is a valuable indicator for informed effect data selection. The MAGIC effect graph will be made available to the public.

Disclaimer/Disclosure: Lara L. Petschick received funding by the Deutsche Bundesstiftung Umwelt. Larissa Z. Hermann received funding from the European Union's Horizon Europe research and innovation programme under Grant Agreement No 101057014 (PARC — Partnership for the Assessment of Risks from Chemicals).

From Research to Society: The Role of Foundations and Other Non-Profit Organizations in Advancing Ecotoxicology and Environmental Science

7.04.T-01 ICEDA: An Intersectoral Model Linking Endocrine Disruptor Research, Policy, and Society

Vicki Marlatt[1], Jan Mennigen[2], Romy Técher[3], Valerie Langlois[4] and Isabelle Plante[4] (1)Simon Fraser University, (2)University of Ottawa, (3)CIAPE-ICEDA (INRS), (4)National Institute for Scientific Research (INRS)

Knowledge mobilization in ecotoxicology toward society represents a major challenge, particularly for complex issues such as endocrine-disrupting chemicals (EDCs) and their multi-systemic effects on wildlife, ecosystems, and human health. Addressing these challenges requires integrated approaches that can seamlessly articulate both the advancement of academic scientific knowledge and its meaningful appropriation by diverse stakeholders, including non-profit organizations, professionals, and civil society, within a unified One Health perspective. The Intersectoral Centre for Endocrine Disruptor Analysis (ICEDA) illustrates the pivotal role that hybrid, intersectoral networks can play as a case study for successful collaboration between academia, foundations, and non-profit organizations and regulators. Originating from an academic initiative and supported by public funding, this structured network relies on a formal collective organization that serves as a central lever to bring together scientific production and its mobilization toward citizens. This cooperative mode of

organization enables ICEDA to actively contribute to environmental and health sciences at the interface of ecotoxicology and public interest. By partnering with non-profit actors, ICEDA supports structuring scientific outputs aimed at establishing the state of knowledge, identifying key scientific gaps, and transforming raw laboratory data into actionable tools for public action and citizen awareness. Building on these synergies, ICEDA develops targeted knowledge mobilization initiatives aimed directly at the public, largely driven by the joint engagement of its members and early-career researchers. These collaborative efforts manifest as science cafés, interactive booths, educational posters, occasional workshops, podcasts, science outreach events and children's books designed specifically as participatory spaces for dialogue and exchange around EDCs at the interface of science and society. Overall, ICEDA's experience highlights the immense potential of structured academic-non-profit collaborations to advance ecotoxicological research while maximizing its societal impact. This presentation will present key characteristics of the network and highlight past and ongoing initiatives, offering a scalable framework for successfully transferring complex environmental science to the public.

7.04.T-02 Developing an Adaptive Monitoring Framework for Lake Sturgeon Restoration Through a Renewable Natural Resources Foundation Planning Grant

Scott Colborne[1], Doug Larson[1] and Ed Baker[2] (1)Michigan State University, (2)Michigan Department of Natural Resources

Lake Sturgeon (Acipenser fulvescens) restoration in northern Michigan's Inland Waterway system has relied on decades of stocking and coordinated conservation efforts among state, Tribal, academic, and community partners. Although thousands of juvenile Lake Sturgeon have been released, uncertainty remains regarding post-stocking survival, habitat use, and movement patterns throughout the interconnected lake and river network. Reliable monitoring frameworks are essential for evaluating restoration effectiveness and informing adaptive management of freshwater ecosystems.

Support from a Renewable Natural Resources Foundation Planning Grant enabled development of a collaborative framework for evaluating Lake Sturgeon restoration using acoustic telemetry. The project addressed two objectives: (1) identify shared research and management priorities among stakeholders and (2) generate empirical information needed to design a telemetry-based monitoring program for Black, Burt, and Mullett lakes and their connecting waterways.

Representatives from Tribal governments, state agencies, universities, regional telemetry networks, and community organizations participated in a facilitated workshop to identify priority ecological and management questions. Concurrently, acoustic receiver range-testing was conducted across multiple habitat types, depths, and seasons to evaluate environmental influences on detection performance and inform telemetry array design.

Stakeholder engagement identified shared priorities related to post-stocking survival, habitat use, movement among lakes and river corridors, and system-wide connectivity. Range-testing results provided site-specific information needed to optimize receiver placement and improve the efficiency of future telemetry infrastructure. Together, these outcomes informed development of a consensus-based monitoring framework and adaptive management strategy for Lake Sturgeon conservation.

This project demonstrates how planning-stage investments can support scientifically rigorous monitoring

programs that advance adaptive management and evaluation of restoration outcomes for threatened freshwater species. By integrating stakeholder priorities with telemetry-based monitoring design, the Renewable Natural Resources Foundation investment established the scientific and collaborative foundation necessary for future assessments of Lake Sturgeon restoration effectiveness in the Laurentian Great Lakes.

Disclaimer/Disclosure: Renewable Natural Resources Foundation - Planning Grant

7.04.T-03 From Research to Society: How the Evertéa Foundation Supports Environmental Health Research and Public Outreach

Damien Baudiffier[1], Delphine Delaunay[1] and Valérie Langlois[2] (1)evertéa Foundation, (2)Institut national de la recherche scientifique, Centre Eau Terre Environnement, Quebec, Canada

Environmental contamination, biodiversity loss, and climate change are among the most pressing global challenges of our time, with their impacts increasingly documented across scientific disciplines. At the same time, public concern about ecosystem degradation and its consequences for both environmental and human health continues to intensify. Together, these challenges underscore the urgent need to strengthen the connection between environmental science and society, while improving the accessibility, communication, and uptake of scientific knowledge in decision-making and public discourse.

The evertéa Foundation is a French non-profit organization dedicated to accelerating research in environmental health, particularly in ecotoxicology and toxicology, while promoting the transfer of scientific knowledge to citizens and stakeholders. Guided by values of scientific excellence, independence, transparency, and societal engagement, the Foundation addresses two major challenges: supporting innovative and interdisciplinary research projects in environmental health and improving link between the scientific community and society.

To address these challenges, the Foundation develops research funding programs through interdisciplinary calls for projects (encouraging applicants to include a social component) and participates in national and European collaborative research initiatives as coordinator or partner. In parallel, the Foundation implements science communication and outreach activities aimed at increasing public awareness of environmental contamination and environmental health issues. These activities include dissemination events, partnerships with academic institutions and other environmental non-profit organizations, and initiatives designed to facilitate dialogue between researchers and citizens.

This presentation will provide an overview of the Foundation's approach, ongoing activities, and collaborative initiatives supporting the advancement of ecotoxicology and environmental sciences. Case studies from funded and coordinated projects will demonstrate how non-profit organizations can foster scientific innovation, strengthen interdisciplinary collaboration, facilitate knowledge transfer, and bridge the gap between research and society.

The experience of the Foundation evertéa highlights the strategic role that non-profit organizations can play in advancing scientific excellence while increasing public awareness around environmental health issues.

7.04.T-04 The Critical Role of Non Government Organizations in Advancing Environmental Science and Ecotoxicology, Réseau Environnement in Quebec

Mathieu Laneuville[1] and Jean Paquin[2] (1)Réseau Environnement, (2)Fondation 2025

« From Research to Society: The Role of Foundations and Other Non-Profit Organizations in Advancing

Ecotoxicology and Environmental Science » -(Track: 7. Policy, Management and Communication)

Non Government Organizations (NGOs) play a critical and positive contribution for environmental and ecotoxicological issues. Such organizations can collaborate with all scientists and stakeholders to improve the quality of the environment and human health. The case of Réseau Environnement, or Environmental Network, will be presented. The organization constitutes the largest group of environmental specialists in Quebec and has made numerous positive contributions to society over the past 50 years. It collaborates internationally with many other such NGOs such as the American Water Works Association. It covers water, air, biodiversity, soil, waste and climate change.

The example that will be presented is the Healthy Water 2.0 initiative. This large assessment of pollution in water bodies, specifically the Great Lakes and St-Lawrence water basin, yielded important recommendations in 2021. Ten issues were covered with actions to be implemented. One is to orient actions according to the health of critical sentinel species such as the beluga population in the St-Lawrence estuary. Another is to orient our actions such as the modernization of our wastewater treatment facilities according to not only conventional standards, but also to unregulated harmful compounds such as endocrine disrupting compounds that have not been adequately considered in our past investments.

This led to the creation of a work group involving 20 recognized scientists, researchers and government representatives to make recommendations to governments and municipalities that will pay billions of dollars in years to come to upgrade our public wastewater facilities. The consensus report was issued on March 2026 and will positively influence the design of these public facilities in order to improve the quality of our aquatic ecosystems and to improve human health.

The organization has made and continues to make several other important contributions to convey science to public policy. Such a NGO provides credible, reliable and recognized services and recommendations to government, municipalities and the private sector. The role of such NGOs cannot be underestimated and organizations such as Réseau Environnement may provide a model in other jurisdictions.

Disclaimer/Disclosure: Réseau Environnement is dedicated to the green economy. Funding is by its members from all parts of society.

7.04.T-05 World Ocean Plastic Planning Center (PLA PLA) in Saga Prefecture, Japan: An Integrated Five-Function Regional Hub for Coastal Plastic Pollution

Yuji Oshima[1], Takashi Inoue[1], Koji Yoshitake[1] and Yuusuke Ueda[1] (1)Carbon Neutral Society Promotion Division, Saga Prefectural Government, Japan

Marine plastic pollution threatens coastal ecosystems, fisheries, and human communities. Saga Prefecture, Japan, faces disproportionate exposure due to its geography; the Genkai Sea and Matsuura coasts receive transboundary litter from East and Southeast Asia. This coastline, within Genkai Quasi-National Park, remains severely contaminated despite regular clean-ups by government, volunteers, and fishers, with plastic accumulation exceeding one meter at inaccessible sites. Addressing this requires removal capacity and a systemic framework integrating education, recovery, monitoring, and international cooperation. Saga Prefecture

is establishing the World Ocean Plastic Planning Center—PLA PLA—opening June 2026 at Cape Hado, Karatsu City. The net-zero facility integrates five core functions: (1) public exhibitions, (2) educational programs, (3) plastic recycling, (4) scientific research, and (5) international cooperation. Visitors engage with the full cycle of ocean plastic management—collection, sorting, crushing, and regeneration—at one site. Educational offerings include training for students and researchers, youth environmental education, and exchange programs. Internationally, PLA PLA hosts symposia for academia, industry, and government, and organizes multi-regional clean-ups to drive behavioral change, advance CSR/ESG goals, and strengthen transboundary collaboration. Scientific research encompasses monitoring transboundary litter flux, polymer-type characterization, and assessing ecological effects of plastic on aquatic organisms. This multifunctional model bridges education, science, and policy. PLA PLA is the first facility globally to integrate these functions across regional and international dimensions, offering a replicable model for sub-national governments to catalyze community-driven action. This presentation reports on the center's framework, monitoring design, and preliminary findings from pre-opening surveys at Cape Hado, including polymer composition and source attribution, with implications for transboundary plastic management in coastal East Asia.

7.04.T-06 Wings Over Water (WOWRI): A Fledgling Nonprofit Research Institute To Facilitate Waterbird and Eagle Research and Monitoring in the Great Lakes and Beyond

Keith Grasman[1] and William Bowerman[2] (1)Wings Over Water Research Institute (WOWRI) and Calvin University, (2)Wings Over Water Research Institute (WOWRI) and University of Maryland

Fish-eating birds, including colonial waterbirds and eagles, have been monitored as sentinels for the effects of environmental contaminants in the Great Lakes since the late 1960s. Bald eagle population studies began in 1961, and colonial waterbird population and banding studies date back to the 1920s. In collaboration with various government agencies and universities, the authors of this presentation have been the principal investigators for multiple projects and programs concerning waterbirds and eagles in the Great Lakes for more than 3–4 decades. While funding support for this contaminants research had been with particularly stable for much of last 15 years, federal funding for multiple waterbird and eagle projects has not been delivered during 2025–26 despite ongoing support from multiple agency scientists and project managers. Consequently, in 2025 the authors and other collaborators formed the Wings Over Water Research Institute (WOWRI) with three main purposes: 1) to facilitate research and monitoring of eagles and waterbirds in the Great Lakes and other aquatic ecosystems (e.g., the Chesapeake Bay), 2) to train the next generation of avian field researchers and environmental scientists, and 3) to engage the general public through outreach and education. While the primary focus is on legacy pollutants and contaminants of emerging concern, other stressors such as infectious diseases, habitat, climate, and food supply also are of interest. By combining expertise into a new nonprofit organization that serves as a focal point for fundraising beyond the capacities of an individual laboratory and/or academic department, a major goal is to attract research support through multiple mechanisms, including government grants, philanthropic foundations, and private citizens, with an emphasis on collaborative and synergistic relationships with other organizations. This presentation will describe case studies of previous research forming the foundation for WOWRI’s mission and early efforts by WOWRI’s scientists and staff to launch the new nonprofit organization.

From Research to Society: The Role of Foundations and Other Non-Profit Organizations

in Advancing Ecotoxicology and Environmental Science

7.04.V-01 Bridging Science and Practice: Collaborative Strategies To Reduce Pesticide Risks in Avocado-Producing Communities (Michoacan, Mexico)

Ana Merlo[1] (1)Centro de Investigaciones en Geografia Ambiental - Universidad Nacional Autónoma de México

In avocado-producing communities of eastern Michoacan (western Mexico), pesticide use has raised concerns regarding environmental contamination and potential risks to ecosystem and human health. However, scientific evidence alone is often insufficient to promote changes in management practices unless it is communicated through participatory and locally approaches. This study presents a science-society initiative developed from the results of a research project that combined social and environmental assessments of pesticide use in avocado production systems. Semi-structured interviews with avocado and maize producers were conducted to document pesticide management practices, perceptions of risk, and decision-making processes. In parallel, pesticide residues were quantified in water and soil samples collected in rivers and agricultural lands of the communities. The findings highlighted opportunities for improve risk communication and management. To address this gap, a participatory workshop was designed based in the research findings and implemented in collaboration with local civil society organizations. These organizations played a key role facilitating engagement with avocado communities and building trust between researchers and stakeholders. The workshop translated scientific findings into accessible and dynamic information and facilitated dialogue on pesticide handling, environmental pathways, exposure risks and feasible mitigation measures adapted to local production conditions. Through interactive activities and collective discussion, participants identified barriers and opportunities for adopting practices with low risk and co.developed strategies aimed at minimizing pesticide impacts while maintaining agricultural productivity. This case study demonstrates how environmental monitoring, social research, and the active participation of non-profit organizations can be integrated to strengthen knowledge transfer and stakeholder engagement. It highlights the value of partnerships among researchers, civil society organizations, and farming communities in fostering locally grounded solutions for reducing pesticide risks in agroecosystems.

Disclaimer/Disclosure: This research was conducted as part of a posdoctoral fellowship funded by the Elisa Acuña Programa of DGAPA-UNAM. Fieldwork activities and workshops were partially supported by the Monarch Butterfly Fund.

General: Policy, Management and Communication

7.05.P-We154 Examining Potential per- and Polyfluoroalkyl Substances (PFAS) Contamination of Private Drinking Water Wells From a Landfill in St. Clair County, Michigan

Rachel Higgins[1] and Rosa Jaiman[1] (1)Michigan Department of Health and Human Services

The Michigan Department of Health and Human Services (MDHHS) evaluated the potential human health risks for residents with drinking water wells located downgradient of the Huron Development Landfill in St. Clair County, Michigan. Sampling results from the landfill's leachate showed the highest detected PFAS concentrations were perfluorooctanoic acid (PFOA) at 117 parts per trillion (ppt), perfluorooctanesulfonate

(PFOS) at 614 ppt, perfluorononanoic acid (PFNA) at 6.72 ppt, and perfluorohexanesulfonic acid (PFHxS) at 294 ppt. These results exceeded the Michigan Department of Environment, Great Lakes, and Energy Part 201 Generic Cleanup Criteria Screening Levels for Residential Drinking Water. After PFAS contamination was identified in leachate from the landfill's waste cells, MDHHS evaluated the fate and transport of the contaminant, where people have contact with the contaminant, the way the contaminant enters the body and the potentially exposed population. Subsequently, 24 private drinking water wells were identified and sampled within a half-mile radius of the landfill for 14 PFAS. PFAS data from the 24 private drinking water wells sampled showed no detections, indicating that residents are not currently being exposed to PFAS. Presently, harmful health effects from PFAS are not expected for nearby residents who consume water from these wells. MDHHS deploys widespread health education to residents in PFAS investigation areas, no matter what their current testing shows. Residents with a private residential well can follow the standard testing recommendations found at our "Care for MiWell" program. This includes extensive education about testing for a wide range of contaminants and broad education about what PFAS are and how they can be avoided from all sources. MDHHS also reminds residents that people can be exposed to PFAS from multiple sources, and we recommend all residents to reduce their exposure to PFAS when and wherever possible.

7.05.P-We155 International Perspectives on Microplastic Research and Future Research Needs

Andrew Barrick[1], Naima Hamid[1] and Tham Hoang[1] (1)Auburn University

Plastic risk assessment has been ongoing for several decades, with recent advancements over the past five years in defining regulatory criteria. As public concern grows, there is increased pressure to develop comprehensive regulatory policies that address plastics and microplastics. Recent meta-analyses, such as the ToMEX initiative, have found that nearly 89% of academic research does not meet the quality criteria needed to develop comprehensive regulatory policies on microplastics, in part due to the research's focus and the lack of widespread acceptance of reporting criteria. This suggests a lack of consensus regarding the risks posed by microplastics and how to appropriately address them. To explore international opinions on microplastics, a survey was conducted to assess the research community's views on the current state of microplastics research and what is needed to address them as a global issue adequately. The survey explored respondents' understanding of microplastics, trends in their home country, attitudes towards microplastic risk assessment, and recommendations for public engagement and policy. The survey received responses from five geographic regions (Asia, Africa, Europe, North America, and South America). A majority of respondents reported public awareness and concern regarding plastic waste. Most respondents had a common understanding of microplastic definitions and agreed that standardization was the primary barrier to microplastic research. Surprisingly, opinions regarding policy recommendations varied between respondents; however, most respondents suggested that product bans were most likely to be most effective in addressing microplastics as an environmental concern. The survey outlines challenges facing microplastic research and potential future research needs to develop comprehensive regulation.

7.05.P-We156 An Innovative National Research Education, Mentoring, and Skills Development Training Program in One Health and Toxicology: MSDT- One Health

La Cole Blackshire[1], Laura Van Winkle[2] and Wilson Rumbeiha[2] (1)University of California Davis, (2)University

of California Davis (UC Davis)

MSDT-One Health (OH) is a 5-yr mentoring and skills development training program with a focus on One Health and toxicology funded by NIH NIGMS. It is a national training initiative comprising a consortium of institutions led by the University of California, Davis, including SETAC, Meharry Medical College, and Iowa State University. One Health research is aimed at optimizing the health of people, animals and the ecosystem in their shared environment. Currently, a major challenge facing One Health (OH) research is the lack of engagement of toxicologists and/or people with toxicology knowledge. This issue partly stems from insufficient training of toxicologists in skills vital for effective transdisciplinary OH research. In addition, OH is not typically available as a major at most undergraduate institutions. To address this gap, MSDT-One Health has been developed with three specific aims (SA). SA1: Develop and deliver a year- long mentoring program for STEM undergraduate students. SA2: Develop and deliver a year-long professional development training and mentoring program for early career scientists (Post-docs, Fellows, Project Scientists, Assistant Professors) to increase their awareness of the opportunities in OH research and to increase their knowledge and ability to obtain funding necessary to conduct OH research, including community-engaged toxicology research. SA3: Develop case studies and e-modules at the intersection of OH and toxicology and make them widely available. Expected outcomes include: a) a total of ~100 undergraduate students mentored in OH with a toxicology emphasis; b) 5-10 early career scientists securing intramural seed funding and 2-3 early career scientists securing extramural funding to conduct OH research with community engagement components; c) development of highly interactive case studies in one environmental health toxicology (5) and learning modules on OH (3) to be widely available for training undergraduates and early career researchers. Ultimately, this research education program in OH and toxicology will strengthen the biomedical research enterprise by increasing the number of scientists with the necessary knowledge to engage in transdisciplinary OH research. Over the first two years of funding, the MSDT-OH program has successfully enrolled 40 undergraduate students,18 early-career scientists, and has built relationships with over 20 senior One-Health and toxicology professionals. Supported by NIGMS R25GM160671

Disclaimer/Disclosure: This research is supported by a grant from the NIGMS R25GM160671.

7.05.P-We157 The Report Card of the Yucatán Peninsula Aquifer (YPA): An Approach to Assessing the Health of This Critical Hydrological Reserve for Sustainability

Elsa Norena-Barroso[1], Paulo Salles[1], Roger Pacheco-Castro[1], Karol Granados-Martínez[2], Armando Carmona-Escalante[2], Gabriela Rodriguez Fuentes[1] and Erick Soto-García[1] (1)National Autonomous University of Mexico (UNAM), (2)Laboratorio Nacional de Resiliencia Costera (LANRESC)

The Yucatán Peninsula Aquifer (YPA) is one of Mexico's most important freshwater reserves and the sole source of drinking water for more than five million people. Its highly permeable karst system, characterized by dissolution conduits and extensive groundwater connectivity, is highly vulnerable to contamination from urban growth, tourism, industry, and agricultural activities. To support evidence-based management of this strategic resource, the National Laboratory for Coastal Resilience (LANRESC) coordinated the development of the first YPA Report Card during 2024–2025.

Developed by the University of Maryland Center for Environmental Science, Report Cards are science communication and governance tools that synthesize complex information into transparent and accessible assessments of ecosystem health. They facilitate stakeholder communication, support decision-making, and

promote collective action toward sustainability.
The YPA Report Card was developed through a participatory process involving 89 stakeholders from academia, government, civil society, and the private sector. Using a six-step framework, the aquifer was divided into nine hydrogeological and socio-economic subregions, including a coastal influence zone to account for groundwater–coastal ecosystem interactions.
Twenty-three indicators grouped into seven thematic dimensions were evaluated. Water-resource indicators revealed contrasting conditions. Groundwater availability received a "Good" grade, reflecting extraction rates below natural recharge in many areas. In contrast, treated wastewater coverage received a "Poor" grade, highlighting deficiencies in sanitation infrastructure. Groundwater quality and vulnerability to saltwater intrusion were rated "Fair," indicating degradation associated with coastal urbanization, inadequate wastewater management, and diffuse pollution. These findings underscore increasing threats to water security and ecosystem integrity.
The overall YPA grade was "C – Fair," indicating moderate socio-environmental health and the need for proactive management. By linking groundwater contamination, land-use change, biodiversity conservation, climate variability, and human well-being, the Report Card provides a systems-based framework for water governance. Through effective communication of scientific information and active stakeholder participation, it serves as a practical tool to support sustainable management of one of the world's largest coastal karst aquifer systems.

7.05.P-We158 Fate À Compris: Using Collective Experience To Build an Open-Source Textbook

Tim Rodgers[1] and Carla Ng[2] (1)University of British Columbia (UBC), (2)University of Pittsburgh

Teaching and learning environmental fate and transport within the modern undergraduate science and engineering curriculum is challenging as students must integrate concepts spanning chemistry, mass transfer, numerical methods, statistics, programming, and related disciplines. To address these barriers, we are developing an open-source textbook and accompanying coding workbooks designed to guide learners from foundational principles to applications in risk assessment, chemicals management, and environmental remediation.
This poster adopts an interactive, participant-driven approach to inform the design of these materials. Drawing on the expertise of SETAC attendees, we will engage participants in a series of structured activities to capture how practitioners in the field learned, conceptualized, and ultimately gained intuition in environmental fate and transport.
Participants will be invited to contribute their perspectives on key questions, including:
1. What concepts were most challenging to understand?
2. What barriers hindered learning?
3. What tools, experiences or people helped you develop understanding?
4. What content or features would you most like to see in future teaching resources?

Responses will be collected and visualized in real time during the session, creating a shared synthesis of community experience. These insights will directly inform the development of our open-source educational materials, with the goal of improving accessibility, intuition-building, and interdisciplinary integration in environmental chemistry education.

7.05.P-We159 Protecting Defense-Critical Applications From Chemical and Material Regulatory Risk

Jessica Lambert[1], Jarquees Williams[2] and Colin Hogan[1] (1)Noblis, (2)Office of the Assistant Secretary of War (Energy, Installations, & Environment)

Chemicals play a vital role in defense-critical applications, providing essential properties, including thermal and chemical resistance, oxidation resistance, and stability, required for mission performance. Critical chemicals and materials used throughout the manufacture, maintenance, and sustainment of defense-critical applications face potential obsolescence due to supply chain disruptions, market phase-outs, liability concerns, and emerging regulations under the U.S. Toxic Substances Control Act (TSCA), the European Union's Registration, Evaluation, Authorisation, and Restriction of Chemicals (REACH) regulation, and U.S. state regulations. Regulatory actions may impact the supply and availability of key chemicals needed for defense systems to meet technical requirements and performance specifications. Viable alternatives may not exist for many of these chemicals; where alternatives exist but are not drop-in replacements, changes to defense system design, qualification, and sustainment processes may be required, introducing additional supply chain fragility and extended timelines for requalification.

The Chemical and Material Risk Management (CMRM) Program enhances readiness and supports national security by identifying and managing these risks across the Department of War (DoW). Using a three-tiered process (scan, watch, action), the CMRM Program monitors emerging regulations, assesses chemical criticality and market fragility across the defense supply chain, and collaborates with the defense industrial base (DIB), other Federal agencies, industry, and academia to develop proactive, fit-for-purpose solutions, including advancing supply chain transparency through full material disclosures, identifying research and development needs for alternatives, and communicating risk to affected stakeholders. This presentation examines the role chemicals play within the defense supply chain, elucidates their critical functionalities for the DoW, and demonstrates how the CMRM Program identifies risk, coordinates with stakeholders, and mitigates regulatory risks to ensure continued chemical and material availability for mission-critical applications.

7.05.P-We160 Predictive Regulatory Compliance Evaluation and Policy Tracking (PRECEPT): AI-Enabled Policy Risk Profiling

Jessica Lambert[1], Nathan Clark[2] and Colin Hogan[1] (1)Noblis, (2)Machine Learning Engineer

Agencies and industry face unprecedented regulatory complexity in managing PFAS (per-and polyfluoroalkyl substances) compliance across installations. This poster presents PRECEPT (Predictive Regulatory Compliance Evaluation and Policy Tracking), an artificial intelligence-driven environmental policy interface designed to transform fragmented regulatory intelligence into strategic compliance management. PRECEPT employs three integrated analytical modules: State Legislation Analysis utilizes natural language processing to analyze legislative developments from all 50 states and applies velocity analysis to establish bill passage likelihood; Regulation Analysis maintains a comprehensive database comparing state-specific standards against Federal Maximum Contaminant Levels, EPA Regional Screening Levels, and (Department of War (DoW) Project Screening Levels; and Policy Intent Analysis extracts underlying regulatory priorities across environmental media through keyword clustering algorithms. These modules synthesize into a Regulatory Risk Index (RRI) providing composite risk scores for each state, enabling state-specific risk profiling. Historical state litigation

data spanning 2005-2025 was incorporated as a proxy measure to assess the delayed impacts of past PFAS regulations and legislative efforts, with statistical time-lag analysis revealing temporal patterns between regulatory implementation and enforcement actions, providing empirical validation for the system's risk assessment methodology.

Leaning in on Safety in an Era of Regulatory and Environmental Uncertainty

7.07.T-01 Relational Safety: Indigenous Knowledge Systems as a Foundation for Resilient and Benign by Design Sustainability Science

Audrey Moores[1], Jody-Lynn Rebek[1] and Elizabeth Edgar-Webkamigad[2] (1)McGill University, (2)Algoma University

In an era of regulatory, environmental, and social uncertainty, safer chemistry and materials cannot be defined only by reducing hazards after products or projects are designed. They also require earlier, more relational questions: what should be made, for whom, with what consequences, and over what time horizon? This presentation offers a case study from a collaborative workshop held in Baawaating, Ontario, with Indigenous knowledge holders, practitioners, scholars, and community leaders, including members from Ketegaunseebee and Batchewana First Nations. The work examines how Indigenous ways of being, thinking, and knowing can strengthen sustainability science and safer innovation by reframing safety as a relationship among people, materials, land, water, non-human beings, and future generations.

In this work, we map parallels and distinctions between Indigenous knowledge systems and other sustainability practices. Systems thinking, circularity, Two-Eyed Seeing, seven-generational thinking, ceremonial practice, and relational accountability offer guidance for resilient product and project development under uncertainty. Rather than relying on Western-centric and reductionist models that privilege endless economic growth, these approaches foreground purpose, intention, stewardship, reciprocity, and long-term responsibility. For safer chemistry, materials, and products, this shift can help avoid hazard vulnerabilities before they are embedded in supply chains, technologies, or development decisions.

The presentation will highlight calls to action for researchers, policy makers, and practitioners. By positioning Indigenous knowledge systems as foundational rather than supplementary, this case study aligns with benign by design and resilience philosophies while expanding what counts as evidence, performance, and success. Leaning into relational safety can support sustainable products, projects, and policies that remain robust amid changing regulations, disrupted supply chains, climate instability, and shifting expectations.

Reference: E. Edgar-Webikamigad, J.-L. Rebek, M. R. Twiss, P. Madeira Antunes, I. Aubin, I. Molina, J. M. Barone, A. Jones, A. Moores, ACS Sustainable Chem. Eng. 2026, 14, 16, 7577–7587

7.07.T-02 Charting a Path Towards Positive Change in an Uncertain World

Miriam Diamond[1], Zhanyun Wang[2], Shengnan Wang[1], Miguel van der Velden[1], Anna Shalin[1], Lin Boynton[1], Matthis Schäfer[2] and Juan Camilo Cardenas Campo[3] (1)University of Toronto, (2)ETH Zurich, (3)Universidad de Los Andes

Transformative change can be painfully slow, uneven and requires concerted and persistent efforts. But starting with a few dedicated early adopters willing to take the first steps, positive change can spread well beyond the

initial adopters. Such was the case with the abolition of slavery first in Denmark-Norway in 1792 and last in Brazil in 1888. So too was the granting of suffrage to women starting with New Zealand in 1893 and ending with Switzerland in 1971. This should inspire continued and unrelenting efforts towards a sustainable and more resilient society, while creating safeguards for those who have been and will be impacted most by a deteriorating environmental and socio-economic conditions along this trajectory.

In an effort to seek positive change, we have been working towards establishing safe and just planetary boundaries to act as guardrails to avoid irreversible damage to the Earth's biophysical systems and human society, respectively. Those guardrails should inspire and guide pathways that lead society through a just transition from the current unequal and unsustainable conditions to an equitable, safe and sustainable world. The pathways need to consider both structural drivers that lock-in entrenched, damaging practices and actors capable of ending those practices.

This presentation will first summarize the concepts and efforts to delineate safe and just boundaries for novel entities. Next, we will present two case studies that illustrate structural drivers that lock-in problematic conditions: the growing prevalence of antimicrobial resistance (AMR) that is increasingly harming people and the environment, and the continuing, if not growing use of mercury in Artisanal and Small Scale Gold Mining (ASGM). For AMR, the structural drivers at a global scale are closely linked to poverty that underpins the use of antimicrobials as a compensating mechanism. For ASGM, the drivers include the rising price of gold, weak economic and regulatory infrastructure, constrained enforcement, and social legitimization of mining livelihoods. These examples, unfortunately, show that there are no quick fixes, but that achieving positive change is possible through sustained and integrated efforts across sectors, countries and actors. This gives us the motivation to keep working towards positive change.

7.07.T-03 Managing Chemical and Waste Considering Multiple Value Systems

Louis Tremblay[1], Jamie Ataria[2], Karen Fisher[3], Ani Kainamu[1], Nikki McRobie[4], Stevie-Rae Blair[4], Dean Whaanga[4], Erica Gregory[5] and Georgina Dowd[1] (1)Bioeconomy Science Institute, (2)Te Ao Mārama Inc, (3)University of Auckland, (4)Te Ao Mārama Inc., (5)New Zealand Environmental Protection Authority

Anthropogenic chemicals are fundamental for maintaining our standard of living in modern society. Unfortunately, some chemicals are persistent and can enter waste streams and, ultimately, the environment. Planetary Boundary has been exceeded for chemicals including plastics (novel entities). To date, current chemical management frameworks have been insufficient to abate the on-going decline in environmental health globally. We offer a novel transdisciplinary approach based on partnerships with scientists, regulators, environmental managers, community representatives and Indigenous people. The research explores the appropriate use of taonga (culturally significant species) for toxicity testing by exploring how new approach methodologies (NAMs) can be incorporated within Māori designed and operated environmental monitoring programs within Murihiku, in Southland New Zealand. The partnership with the Environmental Protection Authority, the New Zealand chemical regulatory authority, academic and science organisations will target opportunities to further strengthen embedding Indigenous knowledge systems and learnings into education, research, policy and regulatory contexts towards achieving mutually respectful understanding of Indigenous methods and evidence. The overall objective is to inform best practice around chemical risk reduction, risk assessment and appropriate management through proper tikanga (right processes) for chemical risk assessment

aligning with key values and aspirations that reflect the local setting.

Disclaimer/Disclosure: Tri-Agency Institutional Program Secretariat: New Frontiers in Research Fund – Transformation (NFRFT-2024-00232)
New Zealand Ministry of Business Innovation and Employment (MBIE) Strategic Science Investment Fund (SSIF) (C09X1704)

Managing Risk and Trust During Transformation of Environmental Risk Assessment Methods

7.08.P-Tu135 Mainstreaming Fish Cell Line-Based Methods: An Expert Workshop to Co-Design the Fish Invitrome Framework

Marion Revel[1], Jessica Bertoli[1], Mihai-Ovidiu Degeratu[1], Maximilian Hoos[1], Christian Binz[1], Ksenia Groh[1], Colette vom Berg[1], Bernhard Truffer[1] and Kristin Schirmer[1] (1)Swiss Federal Institute of Aquatic Science and Technology (Eawag)

Fish cell line-based toxicity assays have advanced considerably over the past two decades and provide valid alternative to in vivo acute toxicity testing for environmental risk assessment. Despite this progress, uptake of these New Approach Methodologies (NAMs) remains slow, which many actors attribute to the lack of regulatory acceptance.
However, regulatory acceptance is often rather the endpoint of a development to overcome the manifold barriers rather than an immediately reachable target. Informed by social science studies on success conditions for radical innovations, we frame the process for overcoming these barriers as “mainstreaming” by analyzing selected industry contexts in which these methods could help to overcome specific barriers, even before full regulatory acceptance is established.
To analyze potential mainstreaming pathways, we organized a two-day expert workshop at Eawag in February 2026, bringing together sixteen European experts from industry, regulatory bodies, academia, non-profit organizations and contract research organizations. Participants were invited to identify barriers and drivers to the application of fish cell assays and to formulate short- to long-term visions across three industry contexts: agrochemical, consumer product and pharmaceutical sectors.
The workshop revealed both shared and sector-specific needs and timelines, and identified training programs, case studies and lighthouse cases of regulatory acceptance as short-term priorities for building trust in these methods across diverse actor groups.
Building on these results, we introduce the Fish Invitrome for animal-free toxicity prediction — a framework under development at Eawag that aims to provide structured guidance on existing and developing fish cell line-based methods across endpoints of regulatory relevance. Designed as a modular and accessible resource, the Fish Invitrome directly responds to the barriers and needs identified during the workshop, with a longer-term vision to evolve into an integrated decision-support toolbox for environmental risk assessment.

7.08.P-Tu136 Application of the Collection of Alternative Methods for Regulatory Application (CAMERA) Database as a Tool for Supporting Chemical Risk Assessment

Alexander Cole[1], Katie Needham[1], Prince Osei-Akyeampong[1], Tosho Agunloye[1], Trey Saddler[1], Jeremiah Mensah[1], Caleb DeGroote[1] and Helena T. Hogberg[2] (1)Dynanet Corporation, (2)NIH/NIEHS/DTT/NICEATM

As ecological and human health risk assessment practices increase the incorporation of validated new approach methodologies (NAMs), there is a global need for a centralized repository that compiles validated alternative test methods to support the transition toward reduced animal use. The Collection of Alternative Methods for Regulatory Application (CAMERA) is a publicly accessible, online resource which aims to effectively consolidate validated NAMs into a single, accessible platform, improving the accessibility of methods and their underlying validation data that was previously scattered across multiple agencies and organizational websites. CAMERA provides end users with the ability to visualize and compare key data and metadata from test method validation studies, including reference chemicals and reference tests employed, as well as performance metrics such as the reproducibility and predictive capacity. By integrating study reports, protocols, performance data, and regulatory guidance into a unified interface, CAMERA enhances transparency and facilitates consistent application of NAMs in chemical safety evaluation. Additionally, using standardized ontology vocabulary and large language models to identify validated NAMs capable of measuring the key events (KEs) of OECD endorsed adverse outcome pathways (AOPs), CAMERA is a resource capable of aiding risk assessment where the domain of applicability for a given KE or AOP are in scope.
While CAMERA provides an efficient, user-friendly platform that significantly enhances access to validated and qualified NAMs, the database remains ever-green; updating end user functionality through the addition of new features and NAMs. Ongoing development will expand method domains, strengthen interoperability with other databases such as the NIH Integrated Chemical Environment (NICE) and the AOP Wiki, integrate new tools for enhanced interactive capabilities, and continue to integrate user feedback to strengthen CAMERA's utility.

Disclaimer/Disclosure: This research was supported by the National Institutes of Health under contract 75N93025R00023. The content presented in this abstract are those of the authors and do not necessarily reflect the views of the National Institutes of Health or the US Department of Health and Human Services.

7.08.P-Tu137 Uncertainty Avoidance in New Approach Method (NAM) Innovation: Impacts on Intrapreneurial Activity and New Technology Acceptance in Regulatory Settings

Paris Jeffcoat[1], Gordon Hickey[1], Steven Maguire[2], Rebecca Dalton[3] and Niladri Basu[1] (1)McGill University, (2)University of Sydney, (3)Environment and Climate Change Canada (ECCC)

To fully realize the potential of new approach methods (NAMs) for regulatory decision-making, there needs to be a shared responsibility among NAM innovators (e.g., NAM developers and adopters) for understanding, assessing, interpreting and, where necessary, reducing technical uncertainties (i.e. uncertainty about a NAM's accuracy in providing a 'protective' point-of-departure for risk assessment). In precautionary settings, how do NAM innovators approach and engage with different types or sources of technical uncertainty? How might 'uncertainty avoidance' influence an individual's intra- or entrepreneurial behaviour, i.e., their willingness to take and/or bear (calculated) risks associated with NAM adoption? How might their organization's prevailing

'risk culture' influence NAM adoption, acceptance, and innovation?

In this study, we consider how uncertainty avoidance influences intra- and entrepreneurial intentions and attitudes towards new technology acceptance and consider the potential moderating effect of intra/entrepreneurship on intention to use NAMs in innovation environments. 31 key expert semi-structured interviews were conducted with a diverse range of NAM innovators from five jurisdictions (Australia, Canada, Europe, UK, and US). Results suggest that uncertainty-avoidance influences new technology acceptance and intra/entrepreneurship among NAM innovators. For example, individuals who tried to embrace and resolve the uncertainty and unknowns associated with NAM data perceived NAMs to be more useful and easier to use. Similarly, individuals embedded in risk-tolerant organizational cultures showed more intention to use NAMs in their work and demonstrated dimensions of intra/entrepreneurship such as risk-taking, self-determination, and proactivity.

This study provides a snapshot of the implications of NAM innovators' approaches to technical uncertainty for the risk taking associated with intra- and entrepreneurial activity necessary to drive NAM acceptance and adoption. Overall, these insights advance understanding of obstacles and drivers of NAM adoption in regulatory settings and can inform evidence-based policy and guidelines for NAM adoption and use.

7.08.P-Tu138 Impacts on Post-Modern Philosophy on Science and Risk Communication

Scott Dyer[1] (1)LeTourneau University

Public trust in science has been decreasing over time as evidenced by a logarithmic increase in journal retractions over several decades. Whether environmental scientists like it or not, research has increasingly become fraught with public skepticism that will impact policy and decision-making. This coupled with the observations that opinions outweigh facts is indicative of a post-modern philosophy. Post-modernism is characterized by skepticism and relativism. Taking it to its ends, a post-modernist may advocate there is no such thing as truth. It is no wonder that science and its diverse forms of communication are at risk. Scientists involved in studying the relationships between polymer chemistry and plastics understand the difficulty in educating fellow scientists and the public. Communicating the differences between various monomers, oligomers, polymers and plastics requires a deep knowledge of chemical structure and how it relates to environmental fate and potential risk. For example, there are terms used in scientific literature and social media that use the term "liquid plastics". This term could refer to the pre-mold state of thermoset or thermoplastics. However, the term is most often used for polymers that can be dissolved in water, a violation of the definition of plastic. Polyethylene glycol is soluble, yet polyethylene (PE) plastic is not. The overlap in terminology confuses the public and decision-makers. Another example is "polyvinyl", where polyvinyl chloride (PVC) is a well-known insoluble plastic, yet polyvinyl alcohol's (PVA) properties are based on the degree of hydrolyzation of the polyvinyl acetate and cross linking. Properties of PVA range from soluble gels, films and textile coatings and adhesives. The reception of such nuances by experts is often put aside by decision-makers to an "end justifies the means" perspective (post-modern) potentially leading to inappropriate actions and judgements. Are scientific quibbles of accuracy (truth) the only method to tackle communicating science in a post-modern world? Or should more dramatic methods be considered that directly call into question the philosophical underpinnings of a particular issue? If the former, science is a losing proposition. If the latter – there is hope for science and communication, though painful.

Success Stories on the Utilization of Long-term Contaminant Monitoring Data and Information to Assist in Decision Making and Strategic Planning

7.10.P-Tu299 What Internal Residues Reveal About Pesticide Risk in Juvenile Chinook Salmon

Michael Lydy[1], Hadis Miraly[1], S.D.M. Chinthaka[1], Kara Hiff Hartz[1], Shawn Acuna[2] and Amelie Segarra[3] (1)Southern Illinois University, (2)Metropolitan Water District of Southern California (MWD), (3)University of California Davis (UC Davis)

Declines in Chinook Salmon populations in the Sacramento–San Joaquin Delta have been linked to possible pesticide exposure during outmigration. To better address the role pesticides have on the success of juvenile salmon as they outmigrate, we have developed a series of response spectrum models (RSMs) which link internal pesticide residues in the fish to sublethal endpoints. Endpoints included shoaling, locomotion, olfactory, swim performance, anxiety, growth, upper thermal tolerance and lethality, while the target pesticides included the current-use insecticides bifenthrin, fipronil and its metabolites (fipronil sulfone, fipronil sulfide, fipronil desulfinyl, the legacy degradation product 4,4′-dichlorodiphenyldichloroethylene (DDE). The RSMs then were applied to hatchery-released field-caught juvenile salmon (2022–2025) along migration corridors to evaluate the influence of residency time, release origin and timing, and migration route, on contaminant burdens. Whole-body residues were quantified as lipid normalized concentrations. Pesticide residues increased significantly with residency time, with approximately six-fold and four-fold increases observed from <10 days to >40 days, for bifenthrin and DDE, respectively. Fipronil and metabolite detection frequency decreased over the study period suggesting that the registration changes made in 2017 have made a positive impact on fipronil exposure in the aquatic system. Multivariate analysis identified migration route, release timing, and residency time as significant predictors of contaminant accumulation. Certain migration routes resulted in elevated residues for bifenthrin and DDE, and these pathways included the Feather and San Joaquin Rivers. The bifenthrin residues in salmon from these systems exceeded the levels associated with changes in shoaling and locomotion behaviors, implying that the residues were high enough to alter behaviors that may be associated with an increase predation pressure during outmigration. The developed RSMs provide managers with an approach to target critical outmigration corridors where pesticide exposure may be a problem while removing the need to assess pesticide bioavailability or routes of uptake. Finally, linking internal pesticide residues to sublethal endpoints and predation using life cycle models will allow the assessment of pesticide exposure in Chinook Salmon at the population level.

7.10.P-Tu300 Ensuring Adaptability and Applicability of Long-Term Contaminant Monitoring Initiatives: A Discussion of NOAA's National Mussel Watch Program Current Practices and Future Approaches

Nicholas Castillo[1], Lauren Swam-Jaramillo[1], Mary Rider[1], Arina Morozova[2], Kimani Kimbrough[1], Erik Davenport[1], Michael Edwards[1], Felipe Arzayus[1] and Dennis Apeti[1] (1)National Oceanic and Atmospheric Administration, (2)USPS

The maintenance of long-term contaminant monitoring programs, which are critical tools for establishing and providing the historical baselines necessary to guide future management and research efforts, faces inherent challenges related to evolving management priorities, budgetary constraints, variable end-user needs, and the

dynamic nature of the systems in which they operate. This short communication explores these difficulties, proposes adaptive strategies, and highlights the National Oceanic and Atmospheric Administration's (NOAA) ~40-year continuous national contaminant monitoring initiative, the National Mussel Watch Program (MWP), as a principal case study. We identify and discuss three adaptive strategies to ensure the continued applicability and longevity of such programs: 1) Emphasizing stakeholder engagement, 2) Refining data collection, evaluation, and analysis, and 3) Ensuring data accessibility. Through the implementation of these adaptive measures, long-term contaminant monitoring programs, such as the MWP, can continue to fulfill programmatic mandates, serve as the provider of applicable baseline contaminant data, navigate shifts in contaminant monitoring priorities, and tailor data products to best meet the present and future needs of managers and stakeholders.

7.10.P-Tu301 Seeking Planetary Boundaries: Global Mapping of Chemicals in Humans and Environmental Media

Anna Shalin[1], Matthis Schäfer[2], Lin Boynton[1], Lixi Wang[3], Andrew Hicks[1], Nathan Bergman[1], Derek Muir[1], Meredith Franklin[1], Marc Andre Verner[4], Zhanyun Wang[2] and Miriam Diamond[1] (1)University of Toronto, (2)ETH Zurich, (3)Peking University, (4)Universite de Montreal

The planetary boundaries framework, introduced by Rockström et al. (2009), identified chemical pollution as one of nine boundaries determining Earth's stability and resilience, delineating a safe operating space for humanity. Steffen et al. (2015) changed the boundary to "novel entities" that we define as anthropogenic chemicals and materials, and naturally occurring chemicals for which humanity has altered their biogeochemical cycling. Persson et al. (2022) concluded that this planetary boundary was transgressed based on the number of chemicals produced and released to the environment that exceeds the global capacity for assessment and monitoring, let alone management.

In 2022, the framework was further refined by introducing "safe" and "just" boundaries that are intended to protect the biophysical resilience and stability of the Earth system, and to minimize significant harm to human populations today and for future generations, respectively.

This poster presents a collation and analysis of global environmental and human biomonitoring data to advance the development of safe and just boundaries for novel entities. For the safe boundary intended to capture ecotoxicological impacts as a proxy for Earth system disruption, we show results from a harmonized, global database of measured chemical concentrations across multiple environmental media (e.g., air, surface water, groundwater, soil, biota, sediment). We compare these concentrations to vetted ecotoxicological benchmarks collected from 37 countries to calculate unsafe exceedances expressed as risk quotients.
For the just boundary, we show results from our database of chemical biomarkers measured in human populations compiled from different matrices (e.g., blood, human milk) reported by national and international human biomonitoring initiatives. We identify exceedances based on calculated hazard quotients from measured concentrations in our database and vetted health-based guidance values.

Aggregating these data from regional to global scales enables identification of priority pollutants (e.g., chlorpyrifos in surface waters, PFOS in breast milk) and geographic hotspots (e.g., sites of surface mining, oil extraction and spills) which we visualize through spatial maps. This assessment provides the foundation for a

meta-analysis aimed at informing the status of novel entities relative to safe and just planetary boundaries.

7.10.P-Tu302 NOAA National Mussel Watch Program: Four Decades of Coastal Contaminant Monitoring Supporting Environmental Management, Restoration, and International Collaboration

Dennis Apeti[1], Felipe Arzayus[2] and Lauren Jaramillo[2] (1)National Oceanic and Atmospheric Administration (NOAA), (2)National Oceanic and Atmospheric Administration

The NOAA National Mussel Watch Program (MWP) marks 40 years of environmental stewardship, reflecting decades of scientific, regulatory, management, and international achievements that demonstrate its enduring value and broad impact. Established in 1986, MWP is one of the longest-running coastal contaminant monitoring programs in the United States, providing consistent, nationwide data on chemical contaminants and biological stressors in coastal and estuarine ecosystems. These long-term national baseline datasets are critical for evaluating contaminant trends, identifying emerging chemical stressors, and assessing the effectiveness of environmental regulations, including the Clean Water Act and Clean Air Act.

The program monitors more than 600 analytes, including trace elements, pesticides, PAHs, PCBs, flame retardants, pharmaceuticals, endocrine-disrupting compounds, PFAS, tributyltin (TBT), and other emerging contaminants. Its open-access, georeferenced datasets support coastal resource management, seafood safety, ecosystem health assessments, citizen science, and national environmental reporting. MWP data have also been essential for emergency response and damage assessment following major environmental disasters such as the Deepwater Horizon oil spill, Hurricane Katrina, and the World Trade Center collapse, while also supporting restoration and adaptive management in regions including the Great Lakes Areas of Concern, Chesapeake Bay, and San Francisco Bay.

Beyond national applications, MWP has helped inspire and support regional coastal monitoring efforts in the Gulf of Alaska, Gulf of Maine, National Park Service Alaska programs, and state initiatives such as the Washington Department of Fish and Wildlife Toxic Biological Observation System (TBiOS). Internationally, MWP tributyltin (TBT) data informed International Maritime Organization negotiations that led to the Anti-Fouling Systems Convention restricting TBT use on commercial vessels. Additionally, the program contributed to the establishment of the International Mussel Watch Program under UNESCO-IOC and UNEP.

Through integrated monitoring, research, data management, and collaboration, MWP continues to advance coastal ecosystem health assessment, emerging contaminant detection, supporting restoration, and management decision-making.

Disclaimer/Disclosure: The views expressed in this communication are those of the authors and do not necessarily reflect those of NOAA. Mention of trade names, commercial products, or firms does not constitute endorsement by the U.S. Government.

Success Stories: Translating Science into Action to Effect Positive Change

7.11.P-Tu303 Co-Developing Research Priorities With Practitioners: Alternatives to Plastic Case Study

Sarah White[1], Brooke Saari[2] and William HJ Strosnider[3] (1)Clemson University, (2)South Carolina Sea Grant Consortium, (3)University of South Carolina - Baruch Marine Field Laboratory

Broad practitioner engagement is critical to applied environmental research, particularly when project outcomes depend on the adoption of new materials or practices. As part of a NOAA Marine Debris Challenge grant, From blue-gray to blue-green: facilitating the transition to non-plastic, natural material use within the coastal zone economy, our team convened a practitioner advisory council and hosted a two-day facilitated workshop to identify current plastic uses and opportunities for non-plastic alternatives in coastal restoration, oyster aquaculture, and water quality applications. Day 1 engaged practitioners in three structured activities. First, participants identified commonly used plastic materials within each sector and discussed barriers to replacement. Second, participants prioritized research targets through a gallery-walk voting exercise. Third, participants identified information pathways and target audiences needed to support adoption of alternative materials. Day 2 focused on project-team synthesis and interpretation of practitioner input. Across sectors, participants identified recurring barriers to adoption, including cost, material availability, performance uncertainty, policy and specification constraints, and limited awareness of less visible plastic uses. Results also indicated that barriers and solutions differ by audience. Technical professionals emphasized the need for performance data, specifications, and training. Regulators and public agencies highlighted the importance of standards, permitting, and procurement pathways. Businesses stressed commercial feasibility, including cost, supply, and operational fit. Public and community audiences pointed to the need for accessible, place-based communication that builds legitimacy and support. Participants also identified multiple dissemination pathways needed to increase adoption, including professional meetings, outreach materials, public engagement, media, and youth education. Collectively, these pathways were seen as necessary for moving alternatives from unfamiliar and experimental to visible, credible, and practical. This workshop demonstrates how structured practitioner engagement can inform research prioritization and improve research-to-application pathways by aligning materials testing and outreach strategies with the institutional, economic, and social conditions that shape adoption of non-plastic alternatives.

Disclaimer/Disclosure: This abstract was prepared as a result of work sponsored by the South Carolina Sea Grant Consortium with NOAA and the Department of Commerce financial assistance number NA23OAR4170175

7.11.P-Tu304 Bridging the Gap: Mobilizing Investment for Community Resilience in High Point, NC

Kylara Mundy[1] (1)GHD

With evolving political conditions, competing priorities, and increasing natural hazard frequency and severity, it is often difficult for cities to understand what resilience needs are appropriate, let alone obtain the financing needed for critical resilience projects. This presentation identifies opportunities for new funding mechanisms for resilience projects using the city of High Point, North Carolina as a case study. High Point is city with

approximately 120,000 people located in the central portion of North Carolina. This location was of interest because of historical resilience related concerns/incidents and because of the biannual furniture market, which generates over $6.5 billion in economic impact for the state of North Carolina.
The evaluation connected data-driven analysis to the city's capital improvement planning to recommend a reliable, forward-looking financial approach focused on engaging public-private partnerships and local businesses to invest in resiliency projects. This project utilized a literature review, GIS analyses of vulnerability and flood risk data, and investment research to create a wholistic approach to resiliency planning for High Point. Recommendations for the city included areas of focus for resiliency work, integration of resiliency into existing capital improvement projects, and avenues to increase public-private partnerships for co-development of projects.
This work illustrates the value of thoughtful analysis and communication throughout planning, which can also be transferred into risk evaluation. Specifically, communication and planning could focus on a conceptual site model (CSM) to exclude/include information that could be made moot with changes to increase resiliency. Similarly, such resiliency planning could also materially impact not only the calculations in a risk assessment but any resultant cleanup as infrastructure changes are implemented. These sort of sustainability measures, therefore, also should have a meaningful impact on planning when it comes to environmental investigation, assessment, and remediation.

7.11.P-Tu305 A Pioneering Partnership To Protect Vermont Schoolchildren From Toxic Environmental Contaminants: The Story of Its Formation, Milestones, and Impact

Emma Knobloch[1], Shannon Lea Watkins[1], Kathleen Delgado Villatoro[1] and Jason Hua[1] (1)University of Iowa

Polychlorinated biphenyls (PCBs) are persistent environmental contaminants associated with adverse health effects and remain present in many school buildings constructed before a ban on PCB production in 1979. Translating emerging environmental health science into regulatory action often takes substantial time, and academic-government partnerships may help accelerate this process.

This study examined how an academic-government partnership between the Iowa Superfund Research Program (ISRP), the Vermont Department of Environmental Conservation (DEC), and the Vermont Department of Health (Health) was formed and maintained within Vermont's pioneering program to test for and remediate PCBs in K-12 public and approved-independent schools. We sought to identify key partnership milestones and examine challenges and lessons associated with academic-government collaborations addressing environmental contaminants. We interviewed ISRP researchers and Vermont regulatory partners, observed meetings and site visits, and collected project documents and media publications. Using inductive and deductive coding and reflexive thematic analysis, we identified themes related to partnership formation, sustainability, and impact. We analyzed media publications to document public responses to Vermont's regulatory program. We integrated findings using a timeline to identify partnership phases and turning points.

We identified four phases of partnership development between 2021 and 2025: identifying the public health problem, early connections, building a novel program, and formal partnership. State officials were required to make sense of and respond to unprecedented PCB contamination in the absence of established protocols. The partnership facilitated exchange of scientific and regulatory expertise that supported program development and provided unique scientific opportunities. Trusting relationships helped sustain collaboration during periods of

uncertainty and external scrutiny. Early relationship-building, shared commitment to public health goals, and mutual benefit were critical to partnership longevity and implementation success.

This partnership between regulatory and academic groups streamed the integration of research and practice. This model of embedding scientific research within a regulatory program may help other jurisdictions strengthen translation of evidence to action when addressing emerging environmental health challenges.

Who Safeguards Scientific Integrity? A Call to Collective Responsibility

7.12.T-01 Tackling Misinformation With Stronger Demands for Transparency

William Goodfellow[1], Patrick Guiney[2] and Timothy Canfield[3] (1)Exponent, Inc., (2)ECOTOX- Guiney Consulting, LLC, (3)US EPA

In combating the on-going assault on the integrity of science, there are three areas that regularly form the foundation for this assault, misinformation, disinformation and censorship in the scientific dialogue. Additionally, issues continue within the scientific community in areas such as data transparency, a fair peer-review process, and the erosion of trust by the public concerning scientific findings. Earlier this year, a session at the Society of Toxicology was held on whether toxicology needs reformation, springboarding from our recent special sessions at SETAC meetings on scientific integrity. It is relatively easy to assign concerns in scientific dialogue when deliberate disinformation occurs, and it should be called out when it is observed. However, misinformation is more difficult to identify and is often much more subtle to resolve. The emerging and exponential growth in the use of Artificial Intelligence (AI) with massive amounts of information, makes it increasing more difficult to stay up with information and even more challenging to evaluate the credibility of this information. This presentation will explore ways that stronger demands for transparency in science are necessary for the public to regain their trust in reported scientific findings and reporting of conclusions based on these scientific findings. As scientists, we need to address misinformation, disinformation, and public perception, evaluating issues from a position of skepticism, pointing out normative science positions and limiting advocacy in our writings, and managing confirmation bias. Scientists and professional societies must allow alternative hypothesis to be proposed, evaluated and results reported for evaluation and scrutiny by scientific peers. Furthermore, professional societies must be open forums for ideas and data to be proposed, presented, dissected, discussed and evaluated without censorship or preemptive cancellation of scientists with alternative theories or ideas. For their part, scientists must work hard to minimize their preconceived biases and recommit to evaluating studies based on the quality of the methods used, the transparency of the data and data analysis, and how the conclusions are supported or refuted by the data. Using case examples, this presentation will provide ways to better identify misinformation, and how transparency in our scientific dialogue is necessary for the integrity of science.

7.12.T-02 From Precaution To Progress: A Collective Responsibility To Update Regulatory Science

Ellen Mihaich[1] (1)Environmental and Regulatory Resources

Science is a dynamic, self-correcting process rooted in the scientific method — one that evolves through

systematic observation, rigorous testing, and the willingness to revise conclusions as new evidence and better methods emerge. Yet this foundational principle is too often undermined in regulatory science, with significant negative consequences for policy, innovation, and public trust. The history of endocrine disruption (ED) assessments offers a compelling case study to illustrate the challenges of regulatory inertia when scientific understanding and methods advance. When endocrine system concerns first arose nearly thirty years ago, standardized test methods and robust interpretive frameworks were largely unavailable. In the absence of comprehensive chronic data, regulatory decisions were understandably precautionary, frequently labeling substances as endocrine disruptors based on limited information and weak mechanistic signals. Today, after nearly three decades of intensive research, testing protocols have been significantly refined, WoE approaches have matured, and multiple lines of high-quality evidence can now be integrated. However, many current evaluation processes still fail to fully leverage these advances, often continuing to rely on earlier precautionary interpretations rather than systematically incorporating the full range of modern tools and data now available. The costs of not making best use of all that we have learned can be substantial: misguided policies, wasted resources, distrust of regulatory conclusions, and, at times, failure to address more pressing risks. Compounding these issues is often the lack of transparency, not only in the scientific data but in the processes used to select, rank, and interpret studies — including how conflicting evidence is weighed. Particularly troubling is the subjective misuse of "weight of evidence" (WoE), which too often serves as a rhetorical tool rather than a rigorous, reproducible methodology, enabling cherry-picking while maintaining a veneer of scientific credibility. True scientific integrity demands collective responsibility from researchers, peer reviewers, regulators, and other stakeholders. It requires transparent data selection and interpretation processes, high-quality standards, proper application of weight of evidence (WoE), and the courage to revise earlier conclusions when stronger evidence emerges. This presentation will highlight some of these issues with case study examples.

7.12.T-03 A Case Study; Addressing Misinformation Regarding the Environmental Risk of Sunscreens and Beyond

Carys Mitchelmore[1] (1)UMCES, Chesapeake Biological Laboratory

Over the past decade, numerous reports have highlighted the environmental risk of sunscreens, particularly to corals, leading to bans on the sale or use of sunscreens as a proactive measure. This quickly became a highly reported topic across mainstream and social media outlets. However, there is a large amount of misinformation, disinformation, and confusion surrounding this topic-arising not just from conflicting scientific reports, but also product labeling. Ultraviolet filters are a diverse group of compounds with a wide range of commercial applications, including as ingredients in sunscreens. They have been detected in coastal locations, reflecting the extent of local recreational activity.

A decade ago, very few studies addressed this concern, leaving a gap in the measured environmental levels and toxicity data required to conduct formal environmental risk assessments (ERAs). However, the past 10 years has seen a surge in published literature, including a National Academies of Sciences, Engineering, and Medicine (NASEM) consensus committee report in 2022. This NASEM report recommended that ERAs be conducted for all UV filters currently marketed in the United States (both organic and inorganic active ingredients), with results weighed alongside the importance of these chemicals for protecting against skin damage in humans. While a growing body of research is now available for ERAs, their relevance and reliability

differ vastly, with many not suitable for regulatory use. The goal of this talk is to highlight critical caveats and pitfalls in overall study design, the use of solvents, analytical chemistry, and minimum reporting requirements, allowing future researchers to maximize their data's utility for ERAs.

Beyond UV filters, there is an increasing amount of misinformation surrounding basic toxicological principles (such as the binary categorization of 'toxic' versus 'safe' chemicals), the detection of chemicals in environmental matrices, and the broad implications of laboratory results on overall environmental health. These concepts will be critically evaluated. While some points of discussion will be unique to sunscreens, many address the broader misuse of toxicological principles and overreaching assumptions regarding chemical impacts. Ultimately, this case study aims to spark dialogue on our collective responsibility as scientists to combat misinformation, manage bias, and work across all stakeholders to ensure science serves the public good.

7.12.T-04 Blinded Science: Half-Blind, More-Blind, and Less-Blind Peer Review Models and Scientific Integrity Vulnerabilities

Christopher Mebane[1] (1)Self

While SETAC journals have so far escaped scientific integrity scandals that have damaged other journals in the ecotoxicology and environmental science domains, we may just be lucky with this. I make six arguments for why double-blind peer review practices as used in SETAC journals increase vulnerability to scientific integrity lapses over more transparent peer review practices: 1) Obscuring data from reviewers is detrimental; 2) Obscuring sponsorship makes bias harder to detect; 3) Author networks can be revealing; 4) Undue trust and responsibility are placed upon editors; 5) Double-blind reviews aren't really all that blind; and 6) Willful blindness is not the answer to prestige bias.

I offer an alternative approach that could provide a more transparent approach for improving scientific integrity and equity in publishing.

1. Require persistent identifiers, i.e., ORCID, and encourage durable email addresses from all authors, not just the corresponding author.
2. Withhold author information from the review invitation emails:
3. Conduct the review in the usual single-blind style, with reviewers having full access to all the same manuscript materials as the editors, except the cover letter.
4. Cross-review and drop the 'confidential comments to the editor' option: After the editor receives the peer review reports, the editor would emails the reviewers with the recommendations and invites feedback on the other reviewers' reports.
5. Open review reports: Publish the anonymous peer review reports as supplemental materials.

7.12.T-05 Distortion, Deception and Delay: An Author's Exposé on Corruption in Scientific Publishing

Christopher Borgert[1] (1)Applied Pharmacology and Toxicology, Inc.

Scientists initially communicated discoveries through personal correspondence or self-published treatises, often

summarizing a lifetime of work. The birth of scientific journals in 1665 marked a transformative moment; scientific publishing is now an annual global market of $13B – $28B. Exponential expansion of this market over the past 25 years has led to intensified criticism of the scientific publishing industry, focusing on its transformation to a highly profitable commercial enterprise that often conflicts with core scientific values of quality, integrity, transparency, and equitable access. These critiques argue that systemic "publish or perish" pressures, metrics obsession, and corporate profit motives contribute to declining standards, a reproducibility crisis, and erosion of public trust. This talk details disturbing corporate intrusion and interference in scientific publishing apparently driven by the global litigation industry. First-hand, inside information suggests intentional obstruction of an editorial by 66 authors, many of whom top the list of toxicologists worldwide. The publisher's violation of its own editorial policies and practices produced a months-long delay after full acceptance and signing of the publishing agreement. Tactics included imposition of extra-ordinary requirements for external scientific reviews and disclosure statements post-acceptance, reversal of decisions by the journal's scientific editors, breaches of confidentiality executed by the publisher from within its editorial software system, and refusal to commit to a final set of requirements for publication. This talk argues that the current model of scientific publishing is too corrupt for reformation. Instead, new publishing structures are needed, designed to mesh with realigned scientific priorities recently outlined by NIH Director, Dr. Jay Battacharya, which include falsification, replication, and the recognition that publishing and grantsmanship often interfere with discovery.

Disclaimer/Disclosure: The author was not funded for this work. The authors travel to SETAC was sponsored by the Endocrine Policy Forum.

8. Systems Approaches

Advancing Life Cycle Impact Assessment: Emerging Methods and System-Level Approaches

8.01.T-01 Integrating Plastic Impacts Into Life Cycle Assessment: MarILCA Advances in Ecosystem Quality, Ecosystem Services, and Human Health

Anne-Marie Boulay[1], Nadim Saadi[1], Arthur Beteille[1] and Louisa Ospital[1] (1)CIRAIG Polytechnique Montreal

It is estimated that 10 to 40 million tonnes of plastics and microplastics (MPs) are emitted annually into the environment. Once released, they redistribute across environmental compartments, potentially affecting biota and humans through environmental exposure. However, current Life Cycle Impact Assessment (LCIA) methods only partially capture their potential impacts on ecosystem quality (EQ), ecosystem services (ES), and human health (HH). This presentation outlines recent advances by the MarILCA international working group in quantifying these impacts.

For impacts on EQ, characterization factors (CFs) for the physical effects of MPs on biota have been developed for microparticles from 20 polymers, 6 cellulosic materials, and tire and road wear particles (TRWPs), across shapes and sizes representative of real-world emissions. Particle fate is modelled using the SimpleBox object-oriented (SBoo) fate model for microparticles, generating fate factors (FFs) for air, terrestrial, and marine compartments, following USEtox regionalization across eight regions. FFs are combined with exposure and effect factors (EEF), based on hazardous concentration for 20% of species (HC20) derived separately for water,

sediments, and soils, to produce CFs with associated uncertainty, expressed in units compatible with LCIA methods such as IMPACT World+ and ReCiPe.
For impacts on ES, ongoing work focuses on the biological carbon pump (BCP), a key ecosystem service responsible for sequestering approximately 20% of annual anthropogenic carbon emissions. MPs transported to the open ocean may disrupt this process, yet such effects are not currently captured in LCIA. A cause–effect chain is being developed linking MP concentrations to changes in carbon sequestration through three pathways: reductions in phytoplankton and zooplankton biomass, and decreased sinking velocities of zooplankton fecal pellets, enhancing remineralization in the upper ocean and reducing carbon export to depth.
For impacts on HH, recent advances have quantified an effect factor for MPs (expressed in DALYs per kg of ingested MPs). While full CFs are still under development, this enables a preliminary inclusion of MP-related impacts on HH.
These developments are applied in LCA case studies in agriculture, textiles, and food packaging, highlighting the importance of accounting for plastic impacts. Overall, the resulting CFs support better environmental decision-making for plastics and their alternatives.

8.01.T-02 Global, Spatially Explicit Distribution Coefficients for Macroplastic Pollution: Advancing Life Cycle Impact Assessment for Biodiversity Plastic Impact Pathways

Catherine Deschênes[1], Martin Dorber[2] and Francesca Verones[1] (1)Norwegian University of Science and Technology (NTNU), (2)Norwegian University of Science and technology (NTNU)

Plastic pollution is one of the main drivers of biodiversity loss, yet its impacts remain insufficiently captured in life cycle impact assessment (LCIA), leading to potential bias when comparing materials and systems over their lifetime. In particular, the lack of robust, spatially explicit impact pathways for plastic emission limits the relevance of LCIA for decision-making related to plastic products. Current characterization factors (CFs) focused on microplastics and the marine realm, leaving macroplastic, the dominant fraction of mismanaged plastic waste (MPW), largely unaccounted for, especially in terrestrial and freshwater habitats. This study advances LCIA by developing global distribution coefficients describing the transfer of terrestrial MPW to aquatic environments. We introduce the Global Plastic Distribution Model (GPDM), a spatially explicit, watershed-based model that simulates the monthly dispersion and accumulation of MPW over 10 years. The model generates global transfer coefficients from terrestrial systems to rivers and lakes, as well as accumulation coefficients for different land classes. Results indicate that approximately 73% (p5-p95, 40-100%) of macroplastic pollution accumulates in terrestrial environments, while most of the remaining fraction is distributed across river systems, highlighting critical intervention prior to aquatic exposure. These aggregate values mask substantial heterogeneity, as uncertainty analysis reveals strong variability across watersheds driven by differences in size, topography, runoff, and geographical location. This underscores the importance of spatially explicit distribution coefficients for accurately capturing regional and global biodiversity impacts. These findings challenge common LCIA assumptions that macroplastics remain stationary upon emission and provide a quantitative basis for improving plastic-related impact pathways, including the development of endpoint indicators linked to ecosystem damage. Furthermore, this work contributes to harmonization efforts by providing globally applicable coefficients that can be incorporated into existing LCIA frameworks. Overall, GPDM represents a critical step toward developing CFs for macroplastic emissions by integrating spatially explicit distribution processes into LCIA, thereby improving the robustness and decision relevance of biodiversity impact assessments.

Disclaimer/Disclosure: This project was funded by the European Research Council (ERC) under the European Union's Horizon 2020 Research and Innovation Program (grant agreement no. 850717).

8.01.T-03 Environmental DNA As Primary In-Situ Biodiversity Data for Life Cycle Assessment Model Improvement

Vincent Desaulniers Brousseau[1], Tim Driver[1], Adrian Cookson[1], Rose Collis[1], Richard Muirhead[1], Natasha Järviö[2], Ville Uusitalo[2], Jasmine Savallampi[2] and Johan Ekroos[3] (1)Bioeconomy Science Institute, (2)LUT University, (3)University of Helsinki

Biodiversity impact remains one of the most methodologically underdeveloped categories in life cycle assessment (LCA), partly because existing characterisation factors (CFs) are largely derived from modelled biodiversity data rather than primary field observation. This presentation evaluates environmental DNA (eDNA) metabarcoding as a primary-data pathway for developing more ecologically grounded, farm-scale biodiversity indicators and CFs.

Using two complementary proof-of-concept studies, we present a distinct pathway for deriving primary in-situ biodiversity data from environmental DNA (eDNA) metabarcoding and how these can be integrated within LCA frameworks. A study in New Zealand (NZ) sampled freshwater eDNA as a proxy for catchment-scale biodiversity across sites spanning undisturbed reference conditions to active sheep and beef farming. Thirteen metabarcoding assays targeting vertebrates, aquatic invertebrates, plants, bacteria and archaea, fungi, protists, diatoms, and specific indicator taxa were used. This captured genetic material from both aquatic communities and terrestrial species entering waterways via runoff and direct deposition. The second study in Finland characterised terrestrial soil biodiversity on a regenerative pasture farm and semi-natural reference site using fungal metabarcoding, with ongoing expansion to cropland and additional taxonomic groups including plants, insects, nematodes, earthworms, and bacteria.

Together, these approaches cover complementary aquatic and terrestrial domains, representing a step toward a whole-landscape framework capturing biodiversity signals within a single farm system. In NZ, biodiversity was characterised using species richness and a quality-weighted taxon-independent index. In Finland, eDNA-derived fungal richness was used to derive land-stress CFs compatible with four life cycle impact assessment methods.

Comparison with conventional LCA outputs suggested that model-based approaches may overestimate in-situ biodiversity loss in the studied systems, while eDNA-based metrics revealed broader taxonomic signals than those underpinning existing CFs. These findings establish multi-taxon eDNA metabarcoding as a promising primary data source for biodiversity characterisation in LCA. Integrating aquatic and soil eDNA signals offers a scalable route toward ecologically grounded, farm-specific CFs that better reflect observed community composition rather than modelled biodiversity averages.

Disclaimer/Disclosure: Funding from AgResearch Flagship Science Programme's Integrating Science for LCA (PRJ0761781), the Kone Foundation's "Improving biodiversity impact assessment for regenerative farming using LCA and eDNA" (PRJ202308406) and the Strategic Research Council of Finland's BIODIFUL project (grant 345884).

8.01.T-04 Developing Monthly Regionalized LCIA: Application to Arctic Electricity and Heat Production

Edgar Sergues[1], Louis Gosselin[2] and Ben Amor[1] (1)University of Sherbrooke, (2)Université Laval

Recent LCIA methods tend to include or recommend the inclusion of a refined temporal scale. The landscape and meteorological features of the Arctic are subject to high seasonality, and including a monthly resolution to LCIA in Arctic regions is intended to change the Characterization Factors (CF) and the resulting impact scores substantially.
In this study, updated and monthly resolved CFs, regionalized for the region of Nunavik, located in the Arctic, are developped for a set of recommended regionalized LCIA methods of the Impact World + framework. The impact categories that are refined are Freshwater and Terrestrial Acidification, Freshwater and Marine Eutrophication, Freshwater Ecotoxicity, Human Toxicity Cancer and Non-Cancer, and Particulate Matter Formation.
To produce the monthly resolved CFs, two groups of LCIA methods emerge. First are the methods that rely on Source Receptor Matrices and sensitivity of the receiving area. Second are the methods that rely on equilibrium models, on landscape and meteorological data. Outputs from GEOS-Chem and PROFILE are used conjointly with data from the ISIMIP, HYDRO-Atlas, Era5-land, and MERRA2 projects. Then, the new CFs are applied to two case studies of energy generation in the Arctic.
Results show that from one month to the other, CFs values differ by up to several orders of magnitude, and that the ranking of pollutants changes. Also, for Terrestrial Acidification and Freshwater Ecotoxicity, the variations resulting from monthly differentiation exceed the ones from spatial differentiation. Application to case studies suggests that the update of CFs to 2019 alters the results in notable proportions, leading to reversed conclusions from existing CFs in comparative assessments for some impact categories. This study underlines that, depending on the considered impact categories, an assessment of the inventories is necessary to assess whether a refinement of the temporal scale is needed or not.

8.01.T-06 An Open-Source Model for Assessing the Environmental and Economic Sustainability of Hydrogen Across Canadian Provinces

Tongfei Xu[1], Alexandre Bouffard Bouffard[1] and Sarah M. Jordaan[2] (1)McGill University, (2)McGIll University

Hydrogen has the potential to play a major part in reducing carbon emissions, with projections indicating hydrogen may contribute 2–10% of global final energy consumption by 2050. Canada, as a leading hydrogen producer, plans to scale its hydrogen production from 3 million tonnes presently to 20 million tonnes of low-carbon clean hydrogen by 2050. This optimistic projection will account for 30% of the energy delivered by 2050. However, the deployment of low-carbon hydrogen may not achieve such high levels of growth. For example, the environmental benefits of hydrogen produced by renewable-powered electrolysis fall short of compensating for its high economic costs. Further compounding the issue, little public information exists to verify the economic and environmental implications of deploying different technologies across regions. To address this gap, we developed an open-source model that quantifies the life cycle environmental impacts modeled by openLCA and the economic costs of hydrogen production technologies. The model contains 21 hydrogen production methods covering conventional to emerging technologies, with geospatially contextualized results for the 13 Canadian provinces and territories. Furthermore, this model is user-customized and can be easily expanded to other regions and technologies. Preliminary results suggest that biomass-based production

methods yield the lowest carbon avoidance cost in Canada with federal incentives. Still, the availability of biomass constrains biomass-based hydrogen potential. In contrast, Canadian fossil fuel resources mean that steam methane reforming with carbon capture and storage, autothermal reforming with carbon capture and storage, and methane pyrolysis present a competitive niche in the short and medium term, particularly methane pyrolysis with wind electricity coupling credits and revenue from byproducts. In the long term, electrolysis powered by renewables is one of the competitive pathways due to lower residual emissions compared to other technologies. This work is significant for Canada in understanding the environmental and economic implications of hydrogen production pathways, considering the regional heterogeneity across provinces and territories. Moreover, this project's open-source feature can facilitate collaboration between academia, industry, and policymakers at a time when hydrogen-related data remains insufficiently transparent in Canada.

Antimicrobial Resistance in the Environment: Drivers, Reservoirs, Transmission Pathways and the Science-Policy Interface

8.02.T-01 Passive Sampling as a Tool for Monitoring Antimicrobial Resistant Genes in Wastewater and Environmental Waters

Natalie Niro[1], Sarah Jane Payne[2], Stephen Brown[3] and Claire Ellison[4] (1)Queen's University, (2)Supervisor and Principle Investigator, (3)Principle Investigator, (4)MASc Student

Background: Through the One Health lens, understanding the link between Antimicrobial Resistant Genes (ARGs) in the population and the environment is vital, and wastewater is an important node of transmission for ARGs, as effluents are returned to environmental receiving bodies.
Challenge and Aim: We aim to demonstrate that passive sampling materials like granular activated carbon (GAC) and cellulose nitrate membranes can be used to monitor low or variable concentration environments (e.g. wastewater and environmental water) for ARGs and to explore the relationship between solids, wash-out events and ARG recovery.
Multi-phase study: 1. Retrospective analysis of passive samplers to detect ARGs in an upstream wastewater environment. In this proof-of-concept work, DNA extracts from historic upstream samples collected from congregate living locations were analysed for 16 ARGs. 2. Adsorption and desorption kinetics of bacteria and solids, where GAC and cellulose nitrate membranes were deployed at a tertiary wastewater treatment plant. An in-situ 48-hr adsorption curve for total solids uptake, 16 different ARGs and 16s rDNA was constructed. The complementary lab-based desorption study determined the extent of solids and signal loss through wash-out. 3. Performance of passive samplers in a low concentration environment in Lake Ontario.
Key Findings: Passive samplers were able to recover ARGs in upstream sewershed, wastewater treatment plant and in the lake. In environmental waters 10 of the 16 ARGs were detected, showing a wide range of resistance. The role of solids in ARG recovery was nuanced. In the solids-heavy influent, solids and ARG recovery were strongly correlated for both GAC and membranes. In the low-solids wetland water, there was a weak correlation between solids and ARG recovery on passive materials, indicating that bacteria and genes may be separate from solids in some environments. Desorption experiments indicated a matrix of solids, bacteria, and DNA that can be strongly or weakly attached to the surface. Initial environmental sampling shows passive samplers are successful in recovering genetic material despite low solids and in spite of wash-out events, ARGs can still be recovered.

Summary and Relevance: Passive samplers are an accessible and versatile tool that can effectively recover low concentration ARGs in wastewater and environmental water and can tolerate wash-out events.

8.02.T-02 Advancing Environmental AMR Surveillance in Canada: The Public Health Agency of Canada's Environmental Surveillance Strategic Framework

Sigrun Kullik[1] and Jayson Shurgold[1] (1)Public Health Agency of Canada

Canada's Pan-Canadian Action Plan on Antimicrobial Resistance (PCAP) recognizes that antimicrobial-resistant organisms can originate in, and move between, humans, animals, plants/crops, and the environment. Environmental contaminants, such as resistant microorganisms, genetic material, and chemical pollutants originating from municipal, industrial, and agricultural waste can further accelerate AMR development and spread.

AMR surveillance efforts led by the Public Health Agency of Canada (PHAC) have historically focused on the human and animal health sectors. Establishing environmental AMR surveillance to address this evidence gap is challenging, due to a lack of consensus on indicators and methods, and the need for cross-sectoral collaboration and a systems-based approach. As the federal lead for coordinating actions on AMR, PHAC developed the Environmental Surveillance Strategic Framework for AMR (ESSF) to guide efforts to improve access to environmental AMR data that can inform mitigation and management in the Canadian context.

The ESSF was developed through an evidence synthesis incorporating literature reviews, expert working group discussions, and a thematic analysis of semi structured interviews. PHAC engaged with domestic and international One Health experts, to ensure that diverse perspectives and the complex interactions through which AMR can move between One Health sectors were reflected.

The ESSF identifies actions PHAC can take to fulfill PCAP commitments to improve access to environmental AMR data, and highlights the need for a structured, national approach to better understand the environment's role in the development and transmission of AMR. The ESSF milestones provide pathways for increasing intra- and inter-departmental collaboration and capacity to prioritize and close AMR environmental surveillance gaps.

The ESSF helps to advance PCAP implementation and provides direction for PHAC's efforts to obtain data on environmental AMR, associated drivers, and transmission pathways among One Health sectors in Canada. PHAC is collaborating with internal and external experts on pilot projects to test methodologies, develop indicators and generate baseline environmental AMR data. These data will be integrated into the Canadian Antimicrobial Resistance Surveillance System, Canada's national system for collecting, integrating, analysing, and sharing data on AMR and antimicrobial use to inform public health research, policy, and interventions.

8.02.T-03 Sub-Inhibitory Antibiotics Modulate Antimicrobial Resistance Fate in a Biofilm-Grazer System

Alexandre Thibodeau[1], Florence Mouchet[2], van Xuan Nguyen[2], Thomas Moura[2], Marion Vivant[2], Eric Pinelli[2] and Maialen Barret[2] (1)National Institute for Scientific Research (INRS), (2)Centre de Recherche sur La Biodiversité et L'Environnement (CRBE), Université de Toulouse, CNRS, IRD, Toulouse INP, Université

Toulouse 3 – Paul Sabatier (UT3), Toulouse, France

Aquatic environments receive chronic inputs of sub-inhibitory antibiotic concentrations from anthropogenic sources, yet the ecological mechanisms driving AMR dissemination across biological compartments remain poorly characterized. This study examined the bidirectional interactions between river biofilm and Xenopus laevis gut microbiota under sub-inhibitory antibiotic pressure (sulfamethoxazole, ciprofloxacin, trimethoprim; 10 $\mu g \cdot L^{-1}$) using a 12-day microcosm experiment and a multi-omics approach combining 16S rRNA amplicon sequencing and high-throughput qPCR targeting 35 antibiotic resistance genes (ARGs) and mobile genetic elements (MGEs).

Antibiotic exposure and grazer-biofilm interaction restructured bacterial communities in both compartments, with stronger effects on biofilm composition. The biofilm resistome increased moderately under antibiotic pressure, particularly when combined with grazing, with sulfonamide resistance genes (sul1) and integron-associated elements (intI1) showing the strongest responses. In contrast, no significant increase in ARG abundances was observed in the gut resistome, a pattern attributed to compartment-specific biotic resistance rather than biomass reduction. Analysis of bacterial immigration revealed potential bidirectional exchange between gut and biofilm, with asymmetric directions: gut to biofilm immigration exceeded biofilm to gut immigration in relative abundance (Wilcoxon, $p < 0.01$), consistent with the concept of high colonization resistance in gut. This asymmetry was further supported by network analysis showing significantly distinct modular organization between compartments (Adjusted Rank Index = 0.0635, $p < 0.001$) and near-absent hub taxa overlap (Jaccard < 0.17), despite similar global topology. Antibiotic exposure was associated with increased immigration rates without altering overall alpha-diversity, suggesting that community-level network mediated changes in biotic resistance rather than diversity loss.

These findings indicate that the Xenopus gut acted as a selective filter limiting AMR dissemination from environmental biofilms, and that sub-inhibitory antibiotic concentrations modulate this ecological buffering capacity. This work highlights the importance of system-based approaches integrating wildlife gut microbiota and environmental reservoirs for the assessment of AMR transmission pathways in aquatic ecosystems

Disclaimer/Disclosure: This research was supported by JPI-Ocean EU Project [PRESAGE] and Centre National de la Recherche Scientifique (CNRS) at INP-ENSAT/CRBE Lab. We would like to thank for their financial support French National Research Agency (AnR) [ANR-21-AQUA-0003-05].

8.02.T-04 ARG Abundance Reduction Masks Qualitative Resistome Restructuring During Anaerobic Digestion of Municipal Biosolids

Chenxiao Liu[1], Afia Jahin[1], Catherine Caldwell[1], Susanne Kramer[2], David Walsh[3], Jesse Shapiro[1] and Dominic Frigon[1] (1)McGill University, (2)Environment and Climate Change Canada (ECCC), (3)Concordia University

Municipal wastewater sludge is a major reservoir of antibiotic resistance genes (ARGs) and a primary route of their entry into terrestrial environments through land application of biosolids. Anaerobic digestion (AD) is the dominant sludge stabilization process and is widely credited with reducing ARG loads, yet current read-level abundance metrics rarely interrogate whether persisting ARGs originate from the feedstock or represent a qualitatively distinct, digester-adapted resistome with different transmission risk.

We applied an assembly-resolved metagenomic pipeline to primary and secondary municipal sludge processed

under a broad range of conditions, including physicochemical pre-treatments (thermo-alkaline lysis, ozonation, and baro-thermal lysis) and biological barrier fermentation conditions (thermophilic at 55°C, acidophilic at pH<5, and alkaline at pH>9) in two-stage AD systems, alongside single-stage and two-stage mesophilic digester controls. ARG abundance and resistome composition were quantified, followed by metagenomic assembly, ARG annotation, and pairwise average nucleotide identity (ANI) comparisons between feed and digester ARG-carrying contigs linked to metagenome-assembled genomes (MAGs).

Read-level analysis confirmed ARG reduction across all conditions — 83–87% for primary sludge and 26–55% for secondary sludge, with two-stage thermophilic treatment performing best. However, 16% of ARG subtypes appeared to persist through the process (≥95% ANI with feed sequences), while 84% were digestor only and shared less than 95% ANI with feed sequences, indicating origin from anaerobic-specialist taxa co-localizing with mobile genetic elements — reflecting ecological community assembly rather than removal limitations. Notably, Macrolide-Lincosamide-Streptogramin (MLS) resistance genes showed markedly higher rates of contig-level continuity with feed sequences, suggesting class-specific transmission dynamics that warrant targeted risk assessment.
These results demonstrate that ARG reduction and apparent persistence during AD is not simple removal but also involves ecological succession restructuring the resistome. Abundance-based metrics, as currently applied in biosolids risk assessments, fail to capture this restructuring and may mischaracterize transmission risk. Allele-level ARG tracking and MAG-resolved source attribution should be integrated into environmental antimicrobial resistance (AMR) surveillance and policy frameworks.

8.02.T-05 Stability and Variability of Antimicrobial Resistance Gene Signals in Two Adjacent Wastewater Treatment Plants

Rhiannon Punch[1], Anna Majury[2], Paul D Hynds[3] and R Stephen Brown[1] (1)Queen's University, (2)Public Health Ontario, (3)Technological University Dublin

Antimicrobial resistance (AMR) represents a growing threat to human, animal, and environmental health. Excessive and inappropriate antimicrobial use represents the primary catalyst for AMR, allowing resistant organisms to develop and spread. Traditionally, AMR surveillance has typically been indirect via human and animal pathogen testing to optimize treatment. Wastewater AMR surveillance enables population-level monitoring by quantifying genetic targets in composite wastewater samples. This project aims to monitor the presence and distribution of AMR genes in wastewater and explore associations with clinical and pharmaceutical use data through a One Health lens, emphasizing the interconnectedness of humans, animals, and the environment. Retrospective fortnightly samples from two adjacent wastewater treatment plants (WWTPs) serving the population of Kingston, Ontario, were screened for 16 AMR gene targets via quantitative PCR (qPCR). Samples from 2022-2024 exhibited medium to high abundances of AMR genes coding for resistance to beta-lactam, macrolide, and sulfonamide antibiotics, while low-abundance genes included those associated with resistance to carbapenems, vancomycin, and colistin. Seasonal-Trend decomposition and stationarity testing revealed contrasting temporal structures, with genes exhibiting strong long-term or seasonal trends further investigated as “priority genes” for long-term surveillance, while temporally unstable genes may offer complementary insights. Cross-correlation analyses and dynamic time warping of identified priority gene time-series resulted in six ARGs being characterized by stable, community-wide resistance, likely influenced by external drivers affecting both WWTP “sewersheds”. In contrast, three genes exhibited episodic or “event-

driven" behaviours, consistent with localized drivers. Findings suggest that AMR gene abundances in wastewater are impacted by complex interactions between resistance dynamics, population-level changes, environmental fluctuations, and hydrometeorological factors that may vary across adjacent sewersheds. Future work will explore associations between wastewater signals and clinical AMR data including community infection rates and prescription data. Findings will investigate the potential for wastewater surveillance to provide early, population-level insights into AMR dynamics, serving as a complementary tool to strengthen future AMR monitoring and management at local, regional, and global scales.

8.02.T-06 High-Resolution Surveillance of Antimicrobial Resistance Genes Across One Health Reservoirs Using Multiplex Amplicon Sequencing

Afia Jahin[1], Claire Gibson[1], Sukriye Celikkol Aydin[1], Natalia Klimova[1], Ju-Ling Liu[1], Yarina You[1], Naziza Rahman[1], Richard Reid-Smith[2], Carolee Carson[2], Brennan Chapman[2], Ioannis Ragoussis[1], Paul Thomassin[1] and Dominic Frigon[1] (1)McGill University, (2)Public Health Agency of Canada (PHAC)

Antimicrobial resistance (AMR) spreads through complex interactions across clinical and environmental settings, making a One Health surveillance approach essential for understanding transmission pathways. Current AMR surveillance in the food production chain relies largely on phenotypic testing of selected culturable pathogens, limiting detection of resistance genes in diverse microbial communities and environmental reservoirs. Although qPCR and metagenomic shotgun sequencing can broaden surveillance, both have important limitations. The qPCR detects ARG families but cannot identify specific variants, while shotgun sequencing lacks sensitivity and remains costly and complex. To overcome these limitations, we propose a multiplex PCR-based amplicon sequencing approach that enables detailed characterization of ARG variants and their dissemination across One Health reservoirs, and that provides databases search capabilities. The new approach should be 100 to 10,000 times more sensitive than shotgun sequencing and more cost-effective. Preliminary analyses of wastewater and livestock manure samples (collected across Canada in 2019) using the proposed amplicon sequencing identified both common and reservoir-specific ARG variants, highlighting the utility of this approach for One Health surveillance. Tetracycline resistance gene variants (e.g., tetM and tetW) showed distinct distribution of variants among wastewater, cattle, swine, and poultry samples, while several beta-lactamase genes (e.g., blaCTX-M, blaTEM, and blaKPC) variants were shared across multiple reservoirs, indicating potential connectivity and transmission pathways. Besides, high-throughput sequencing data from another study involving wastewater, surface water, and cattle manure samples, identified several ARGs that were shared between environmental and animal reservoirs (e.g., blaOXA48, blaCTX-M, and blaCMY-2), while other ARGs appeared to be reservoir-specific. Distribution of variants in surface water is still expected. Building on these findings, we aim to integrate high-resolution ARG variant data from wastewater, surface water, animal farms, and food products in Montérégie, Québec, into the integrated assessment model for AMR (iAM.AMR) model. Focusing on clinically important beta-lactamases (including ESBL and carbapenemase) and tetracycline resistance genes, the study will improve understanding of AMR transmission pathways and reservoir connectivity within a One Health framework.

Antimicrobial Resistance in the Environment: Drivers, Reservoirs, Transmission Pathways and the Science-Policy Interface

8.02.P-We256 Development of a Rapid, Real-Time Detection Method for Antibiotic Resistant E.coli in Environmental Waters

Gillian Brouwer[1], Rayane Azani[1], Lynne O'Donnell[1] and Stephen Brown[1] (1)Queen's University

The rise of antibiotic-resistance among bacterial pathogens is a concern for health systems globally. Responses to this issue have widely been informed by the One Health framework which integrates action across the human, animal and environmental health sectors. While significant monitoring data is being collected in human and animal sectors, monitoring efforts in the environmental sector have been limited by prohibitive requirements of conventional detection methods. These methods require laboratory facilities, trained technicians and multiple days to complete.

The current study aims to modify TECTA E.coli enumeration methods for antibiotic-resistant E.coli detection. The TECTA microbiology system enumerates E.coli in water samples using a culture-based test in which bacterial growth is monitored by an enzymatic reaction that produces a fluorescent product. This detection method is contained within a benchtop instrument, is easy to use, and generates results in 2-18 hours.

In the modified method for antibiotic resistant E.coli detection, an antibiotic is added to the test cartridge. The current study investigated the growth kinetics of ampicillin-resistant E.coli isolates under the modified test conditions, generated a new enumeration calibration curve, and evaluated the method accuracy for mixed-strain samples. Results demonstrate potential for the use of this modified TECTA method for antibiotic resistance surveillance.

8.02.P-We257 Tracking Antimicrobial Resistance in Quebec's Aquatic Ecosystems: A One Health Environmental Surveillance Framework

Veronika Storck[1], Susanne Kraemer[2], Damien Damien Biot-Pelletier[3], Manuela Villion[3] and David Walsh[1] (1)Concordia University, (2)Environment and Climate Change Canada, (3)Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs

Antimicrobial resistance (AMR) is a major global health threat driven by widespread antimicrobial use and the slow pace of new antimicrobial development. While AMR surveillance is well established in clinical and veterinary settings in Canada and Quebec, environmental monitoring remains limited despite evidence that wastewater effluents, agricultural runoff, and industrial discharges contribute to the spread of antimicrobial resistance genes (ARGs) in aquatic ecosystems. These systems can act as reservoirs of ARGs, supporting their persistence and dissemination through dense microbial communities and horizontal gene transfer.
This study aims to develop an analytical framework for the detection and characterization of environmentally relevant ARGs in Quebec surface waters and sediments. Conducted in collaboration with the Quebec Ministry of the Environment (MELCCFP) and its Centre of Environmental Analysis (CEAEQ), the project combines metagenomic sequencing and targeted quantitative PCR (qPCR) to characterize resistome composition and quantify priority ARGs selected for their environmental relevance, clinical importance, and prevalence in wastewater- and agriculture-impacted systems. Method development is aligned with existing Ministry

infrastructure to support future routine monitoring.
As a pilot study representing key AMR pressures in Quebec, sampling sites were selected in two areas: (1) the Saint Lawrence River downstream of Montreal, influenced by municipal wastewater discharges, and (2) Lake Saint-Pierre and its tributaries, affected by municipal, agricultural, and industrial activities. This design enables assessment of spatial patterns in ARG abundance and composition across contrasting anthropogenic gradients. Samples were collected in May during spring runoff and in August under stable summer conditions with elevated microbial activity. We hypothesize that ARG abundance and resistome composition vary spatially and seasonally in response to differences in anthropogenic influence.
The project will deliver (i) a prioritized panel of ARGs for environmental monitoring in Quebec and (ii) a validated metagenomics–qPCR framework suitable for routine surveillance. By bridging academic and governmental expertise, this work strengthens Quebec's capacity for environmental AMR surveillance within a One Health framework.

Challenges in Agricultural Systems: Balancing Food Production with Environmental Sustainability

8.03.T-01 Mesoporous Silica Nanocarriers for Sustainable Agriculture: Mechanistic Insights Into Foliar Delivery of Micronutrients in Crop Plants

XIAOYU GAO[1] and Subhasis Ghoshal[2] (1)Baylor University, (2)McGill University

Improving agrochemical use efficiency is critical for balancing agricultural productivity with environmental sustainability. Conventional fertilizers and pesticides often suffer from poor utilization efficiency, leading to excessive chemical inputs, environmental losses, and unintended ecological impacts. Mesoporous silica nanocarriers have emerged as a promising platform for more efficient foliar delivery of agrochemicals, including micronutrients and pesticides, due to their tunable structure, cargo-loading capacity, and controlled release potential. However, the mechanisms governing nanoparticle uptake, transport, and transformation within plants remain poorly understood, limiting rational design of these delivery systems. Here, we investigated the in planta fate of a mesoporous silica-based nanocarrier loaded with ZnO nanoparticles (ZnO@MSN; ~70 nm) following foliar application to tomato plants as a model micronutrient delivery system. Using complementary advanced characterization approaches, including synchrotron-based nanoholotomography, mass spectrometry imaging, and synchrotron X-ray fluorescence mapping, we tracked nanoparticle uptake, transport, and transformation within plant tissues. Our results show that the nanocarriers can penetrate the leaf surface and move from the epidermis toward vascular tissues through apoplastic transport, with subsequent long-distance translocation consistent with phloem-mediated movement. Along this pathway, Zn speciation analysis indicates transformation of ZnO nanoparticles into Zn complexes associated with endogenous organic ligands, suggesting release of the active micronutrient cargo followed by biotransformation within plant tissues. These findings provide mechanistic evidence that relatively large engineered nanocarriers (~70 nm) can function as effective foliar delivery vehicles in plants, exceeding commonly assumed size constraints for nanoparticle transport. More broadly, this work supports the development of nano-enabled agricultural delivery systems capable of improving micronutrient and pesticide use efficiency while reducing chemical inputs and environmental losses, contributing to more sustainable food production systems.

8.03.T-02 Nanoclay–Essential Oil Formulations: Promising Natural Antibacterial Agents for Fire Blight Control

Andrea Brunelli[1], Cástor Salgado[2], José F. Fernández[3], Nubia Zuverza-Mena[4], Jason White[4] and Quan Zeng[4] (1)Ca' Foscari University of Venice, (2)Instituto de Ceramica y Vidrio, (3)Instituto de Cerámica y Vidrio, (4)Connecticut Agricultural Experiment Station

Fire blight is a major disease of apple and pear resulting from bacterial infection by Erwinia amylovora, with yield losses reaching up to 95%. Disease management relies heavily on antibacterial applications during bloom; however, its repeated use raises concerns about antibiotic resistance and environmental sustainability. Existing alternatives generally show lower efficacy, highlighting the need for novel control strategies.
In this study, nanocomposite formulations based on nanoclay (BNT) loaded with essential oils (EO) were developed and evaluated for fire blight suppression. In vitro assays showed that oregano EO encapsulated within BNT significantly inhibited E. amylovora growth, with a minimum inhibitory concentration of 5 g L^{-1} for both oregano EO alone (O) and the BNT-oregano formulation (BNT-O).
Field trials conducted over two years (2023–2024) in apple orchards demonstrated that several BNT-EO formulations reduced pathogen populations on blossoms and decreased disease incidence. In 2023, BNT-O achieved the highest disease reduction (76%), approaching antibiotic (streptomycin) efficacy, while other formulations showed moderate control (36–50%). In 2024, however, efficacy of EO–based nanoformulations declined, increasing the performance gap relative to streptomycin. Our findings suggest that BNT can act as an effective carrier system for EOs, enhancing disease suppression
Overall, nanoclay-based formulations offer a promising option for fire blight management using natural antibacterial agents.

Disclaimer/Disclosure: We acknowledge the United States Department of Agriculture Grant No. 2026-67021-46072

8.03.T-04 Biomimetic Synthesis of Zinc Oxide Nanoparticles by Bacillus megaterium and Evaluation of Their Antifungal Properties for Sustainable Agriculture

Teboho Tsotetsi[1] (1)University of Johannesburg

Fungal diseases are a significant threat to global food security, causing substantial crop losses and leading to the heavy use of chemical fungicides, which contribute to environmental pollution and pathogen resistance. The green synthesis of zinc oxide nanoparticles using bacteria offers a sustainable alternative, but the specific extracellular metabolites that drive nanoparticle formation and their contribution to antifungal activity remain poorly understood. This study aimed to evaluate the biosynthesis of zinc oxide nanoparticles using extracellular metabolites of Bacillus megaterium and assess their antifungal effects against maize fungal pathogens. The resulting nanoparticles were characterized with UV-Vis spectroscopy, X-ray diffraction (XRD), inductively coupled plasma mass spectrometry (ICP-MS), transmission electron microscopy (TEM), and energy dispersive X-ray (EDX). The study showed the biosynthesized ZnO nanoparticles with a size of 62.25 nm have a significantly high antifungal activity in comparison to the selected commercially available chemically-synthesized fungicide. This study not only illustrates the ability of Bacillus spp. bacteria to synthesize zinc oxide nanoparticles, which is an eco-friendly alternative in the production of Nano-agrichemicals but the integration with metabolomics offers a promising path in deciphering the chemical and molecular mechanisms

behind the mode of action for green synthesis of nanoparticles using bacteria.

8.03.T-05 Optimizing Silica Nanocarriers for Enhanced Pesticide Uptake and Translocation in Plants

Aysa Hedayati Azar[1] and Subhasis Ghoshal[2] (1)McGill University, (2)Civil Engineering department, McGill University

Pesticides are critical in modern agriculture for increasing the yield of agricultural produce towards fulfilling the food demand of an increasing global population. However, the conventional methods of application of pesticides often suffers from poor targeted delivery which leads to more than 90% loss of pesticides to the environment and subsequent harm to non-target organisms. Nano-encapsulation has emerged as a solution to improve the efficacy of pesticide application by enabling controlled release of active ingredients and preventing premature degradation. Silica nanocarriers offer a promising solution, but optimizing their loading efficiency, release kinetics, and subsequent plant uptake routes for a specific pesticide remains a critical challenge. This study elucidates the optimization of the loading capacity and release kinetics of a common fungicide, azoxystrobin, in mesoporous silica nanoparticles (MSNs) and porous hollow silica nanoparticles (PHSNs) as delivery nanocarriers for. MSNs and PHSNs were synthesized and subjected to various azoxystrobin encapsulation techniques such as sorption-based loading in various solvents, loading via capillary forces in nanoparticle mesopores, and loading via the use of a hydrophobic core. The results demonstrated that loading via capillary forces achieved a higher loading efficiency of approximately 40% in MSN, compared to 5% for the other methods. The comparative analysis elucidates the role of particle design and encapsulation approaches for optimal active ingredient loading and controlled release. The optimized nano-formulations were applied to plants via their foliage or root to compare their uptake and systemic translocation against a non-encapsulated aqueous azoxystrobin solution. Optimal nano-encapsulation strategies increased systemic translocation compared to the non-encapsulated active ingredient following root application by 12% in the stem, 68% in the leaves, and 27% in total uptake 7 days after dosing.

8.03.T-06 Options for Addressing PFAS in Agricultural Systems Through Conservation Programs

Linda Lee[1] and Jennifer Guelfo[2] (1)Purdue University, (2)Texas Tech University

Government conservation programs seek to create incentives for farmers to provide ecosystem services while also maintaining agricultural productivity. Such programs struggle to address PFAS in agricultural systems because of the ubiquity of the contaminants, the lack of effective methods for mitigation or remediation in diffuse environments, and often, the absence of regulatory measures to require action. Considering these conditions, the U.S. National Academies of Sciences, Engineering, and Medicine authored a report providing a framework for the primary U.S. agency responsible for conservation programs on agricultural land to begin responding to the impacts of PFAS contamination. The report explores the pathways through which agricultural lands may be affected and the resulting challenges for on-farm conservation practices. It outlines opportunities to help producers avoid or mitigate PFAS contamination through targeted funding priorities, pilot initiatives, and adapted conservation practices. The proposed framework demonstrates how PFAS considerations can be integrated into conservation efforts, allowing program staff and farmers to identify potential PFAS risks, evaluate management alternatives, and adapt practices over time under conditions of scientific uncertainty.

Potential solutions highlighted in the report include predictive modeling to identify at-risk agricultural lands, development of PFAS-specific conservation practices, sequestration approaches using biochar and other sorbents, vegetative strategies to minimize plant uptake, and management changes to reduce livestock exposure. Finally, progress will depend on coordinated applied research, development of federal guidance on PFAS thresholds in agricultural systems, improved data collection, and training for conservation program field staff to support consistent and informed decision-making.

Challenges in Agricultural Systems: Balancing Food Production with Environmental Sustainability

8.03.P-We001 Potentials of Tree Leaves To Improve Productivity and Mitigate Greenhouse Gas Emissions in Ruminant Farming

Ositadinma Chinyere Ugbogu[1] (1)Department of Microbiology Abia State University, PMB 2000, Uturu, Abia State, Nigeria

In the past two decades, there have been global concerns regarding the environmental impact of greenhouse gases (GHGs), especially carbon dioxide (CO2) and methane (CH4), emitted during ruminant farming. These gases contribute significantly to global warming, which leads to environmental degradation. Researchers have investigated various strategies to optimize ruminant production by improving dietary feed, with the aim of enhancing animal health, reducing energy loss, and decreasing GHG emissions through the use of feed additives such as antibiotics. However, the European Union banned the use of antibiotics in 2006 due to associated risks, including toxic effects on host animals, adaptability of rumen microbes, and adverse effects on humans. This has renewed the search for alternative feed additives without harmful effects. Recently, phytoconstituents from tree leaves have been explored as safer and more effective feed additives to improve animal health and inhibit rumen methanogens. Today, there is substantial scientific evidence that tree leaves have promising potential to enhance animal productivity and reduce CH4 production. Leaves from trees contain various phytoconstituents such as tannins, alkaloids, phenolics, saponins, and essential oils, which have significant potential to favourably modify rumen fermentation, improve reproduction, milk production, and meat quality, and reduce GHG emissions during ruminant farming. This present study therefore evaluated the potential use of various leaves and their phytoconstituents to improve productivity and reduce GHG emissions in ruminant farming.

8.03.P-We003 Calcium Phosphate-Based Nanofertilizers for Controlled and Sustainable Nutrient Delivery

Salem Ghribi[1], Lorenzo Degli Esposti[2], Blaire Steven[3], Nubia Zuverza-Mena[4], Jing Yuan[3], Jason White[4], Pavlo Ivanchenko[5], Deb Jaisi[5], Alessio Adamiano[6] and Michele Iafisco[6] (1)Institute of Science, Technology and Sustainability or Ceramics (ISSMC), National Research Council (CNR), 48018 Faenza (RA), Italy, (2)Dipartimento di Chimica e Chimica Industriale, Università degli Studi di Genova, 16146 Genova, Italy, (3)Connecticut Agricultural Experiment Station, New Haven, CT 06511, USA, (4)Connecticut Agricultural Experiment Station, (5)Interdisciplinary Science and Engineering Laboratory, Department of Plant and Soil Sciences, University of Delaware, Newark, DE 19716, USA, (6)Institute of Nanostructured Materials (ISMN), National Research Council (CNR), 40129 Bologna, Italy

Calcium phosphate (CaP)-based nanomaterials were developed and investigated as multifunctional

nanofertilizers for the controlled and synchronized delivery of essential plant nutrients. The work addresses the low nutrient use efficiency of conventional fertilizers, which are characterized by rapid and uncontrolled nutrient release leading to nitrogen and phosphorus losses through volatilization, leaching, and soil fixation, with consequent environmental impacts.

CaP nanoparticles represent a promising alternative to both highly soluble phosphorus fertilizers and poorly soluble phosphate rocks, providing a controlled and sustained nutrient release capable of better matching plant demand. Their pH-responsive solubility further enables gradual nutrient release under acidic soil conditions, potentially improving nutrient uptake efficiency while reducing nutrient losses. CaP nanoparticles were selected as a versatile inorganic platform due to their biocompatibility, tunable solubility, and ability to incorporate multiple ionic species, in addition to providing calcium and phosphorus as plant nutrients. Urea-functionalized CaP systems were first designed as model carriers for nitrogen and phosphorus co-delivery. The influence of the CaP phase was systematically evaluated by comparing crystalline hydroxyapatite with amorphous calcium phosphate, highlighting the superior performance of the amorphous phase in terms of nutrient loading and release control.

Based on these findings, optimized formulations were developed through potassium incorporation, enabling the preparation of integrated NPK nanofertilizers with improved compositional flexibility and applicability. Further modulation of nutrient release was achieved by incorporating alginate within CaP-based composites. In addition, doping strategies with micronutrients such as zinc, iron, and copper were explored to obtain multifunctional fertilizer systems capable of addressing multiple plant nutritional requirements.

Greenhouse experiments on corn (Zea mays) were performed to evaluate the agronomic performance of the developed nanofertilizers, demonstrating their potential to support plant growth while improving nutrient management efficiency.

Overall, the results demonstrate the potential of CaP-based nanomaterials as efficient and tunable platforms for precision agriculture and sustainable crop nutrition.

Disclaimer/Disclosure: This project was supported by a research grant from the U.S. Department of Agriculture (NIFA 2023-67021-39521)

8.03.P-We004 Smart Silica Nanocomposites Activating Plant Defenses via Enhanced Biomolecule Deposition on Superhydrophobic Monocot Surfaces

Anju Sangwan[1], Nitish Kumar[1], Gurdeep Kaur[2] and Neetu Singh[1] (1)Indian Institute of Technology Delhi, (2)TERI-Deakin Nano-biotechnology Centre (TDNBC), Gurugram

Sustainable management of plant diseases is vital for maintaining food security, particularly due to the significant importance of monocots in global agriculture. The utilization of conventional pesticides, however efficacious, raises concerns regarding environmental contamination, hazards to human health, and the emergence of disease resistance. Herein we propose smart nanocomposites (SNPPECs) that integrate biomolecules to activate the plant immune system, encapsulated in nanoparticles within a polyelectrolyte complex. The polyelectrolyte complex, composed of oppositely charged polymers, augments biopesticide retention by mitigating the hydrophobicity of the leaf cuticle via electrostatic interactions and lowering the surface tension of the formulation. In comparison to the naked biomolecules, the nanocomposites showed improved deposition by reducing the contact angle on rice leaves by 31°. Moreover, the control efficacy of SNPPECs against Xanthomonas oryzae pv oryzae was 87%. Our research illustrates the efficacy of nanocarriers

in enhancing plant protection, thus aiding in environmentally sustainable disease management approaches.

8.03.P-We005 Chemical Exposure in Global Food Trade and Responsibility

Elsai Mati Asefa[1] and Frank Wania[1] (1)University of Toronto

Modern agri-food systems have increased food availability and dietary diversity, but they also redistribute chemical pressures across production regions, supply chains, and consuming populations. Sustainability assessments of food trade commonly account for land, water, carbon, nutrients, and biodiversity impacts, whereas chemical exposure remains less integrated. We systematically reviewed studies spanning multiple chemical classes, food commodities, and spatial scales from the city to the global level on how food trade redistributes contaminant exposure and shapes responsibility. We distinguished embedded flows, in which chemicals are physically present in traded food and can contribute to dietary intake, from embodied flows, in which trade reallocates upstream chemical use, emissions, hazards, or footprints to the final demand that drives production. Evidence shows that food trade can increase or reduce exposure depending on commodity origin, contamination level, chemical behavior, dietary demand, and substitution between imported and domestic foods. Exposure and exposure-relevant burden often concentrate in a small number of commodities, origins, or bilateral links, suggesting that targeted monitoring, sourcing standards, and trade-informed dietary guidance may be more practical than broad trade restrictions. Consumption-based accounting can assign upstream chemical pressure to final demand but often does not identify exposed receptors. Dietary exposure assessment identifies receptors but rarely assigns the production activity, consumer demand, or trade link that generated the chemical use or release. Sustainability assessment of the agri-food system rarely captures this dimension. Because the planetary limit for novel entities concerns absolute chemical pollution rather than its relative displacement, reducing impacts from farm to fork requires connecting where chemicals are used and emitted with where exposure ultimately occurs, so that shifting a burden to a producing region is not mistaken for reducing it. We show that this integration is technically feasible but methodologically fragmented, and outline how production-, trade-, and exposure-side analyses can be linked to assess and govern chemical pollution as an explicit agri-food sustainability target.

8.03.P-We006 Polymeric Controlled-Release Systems for Efficient and Environmentally Sustainable Applications of Pesticides

Sunidhi Devi Mehla[1] and Xianming Zhang[1] (1)Concordia University

Pesticides are commonly used in modern agriculture to prevent plant diseases and insect pests, promote the growth of agricultural product output, and meet the food demand of the increasing global population. Recent advance to enhance the safety, efficiency, and sustainability of pesticide application involves the development of nanometer-sized carriers for the delivery of active pesticide ingredients. However, conventionally designed nanocarrier formulations have presented several drawbacks, particularly the uncontrolled and delayed release of encapsulated pesticides. Stimuli-responsive degradation is a promising platform that involves the incorporation of degradable covalent bonds into the design of polymeric materials. When needed, the bonds can be cleaved in response to external stimuli found in environments, insects, and plants, causing the disintegration (or dissociation) of the nanomaterials, leading to the enhanced release of encapsulated bio-active molecules (e.g. pesticides). Boronic ester bond is created through a facile esterification of pendant diol with boronic acid at

room temperature with no aids of catalysts. The bonds can be cleaved in environments such as both acidic and alkaline pHs as well as the presence of reactive oxygen species. Despite these unique properties, boronic ester chemistry has not been studied for controlled pesticide delivery, to our best knowledge.
The project is structured around four interconnected research components: polymer conjugation, aqueous self-assembly, cargo encapsulation, and environmentally triggered degradation and release. Particular emphasis is placed on understanding how molecular weight, degree of functionalization, amphiphilic balance, and formulation conditions influence the physicochemical properties and performance of the resulting nanoassemblies.Encapsulation studies evaluate the capacity of the nanoassemblies to incorporate hydrophobic active ingredients and determine how polymer composition and amphiphilic balance influence loading efficiency and carrier stability. Finally, degradation and release studies examine the responsiveness of boronic ester linkages to environmentally relevant stimuli and their influence on nanoparticle disassembly and cargo release kinetics.The findings will support the development of next-generation controlled-release formulations that enhance pesticide utilization efficiency while reducing environmental contamination and unintended ecological impacts.

8.03.P-We007 Resolving Manganese Deficiency in Tomato Plants With Foliar Application of Manganese (II, III) Oxide Nanoparticles Encapsulated in Mesoporous Silica

Danielle Herman[1], Amanda Del Balso[1] and Subhasis Ghoshal[1] (1)McGill University

With expected human population growth of two billion by 2050 and increasing impacts of climate change on agriculture, technological advancements are needed to increase food production to levels that will adequately support the future population. Crop fertilization is necessary for increasing crop yields, but current fertilization practices are unsustainable. As little as 10% of applied products are taken up by plants, and the remainder is lost to the environment, resulting in adverse impacts such as eutrophication and greenhouse gas emissions. This is especially true for micronutrients that are easily immobilized in soil, such as manganese. Manganese is an essential micronutrient for plants that plays a role in photosynthesis, respiration, hormone signaling, and stress resistance. Manganese deficiency is a major problem in many agricultural soils and can have a devastating impact on crop yields. Foliar nanofertilization, the use of nano-sized capsules containing fertilizer nutrients applied to leaves, is a promising method for targeted nutrient delivery that can bypass the soil system, allowing for improved mobility and efficiency while also reducing environmental impacts of fertilization such as runoff and pollution. Nanomaterials are ideal because manganese salts can scorch leaves, and dissolved manganese does not translocate away from dosed tissues to new plant growth. Mesoporous silica nanoparticle (MSN) carriers have emerged as a good candidate for sustainable nanofertilization due to their biocompatibility, durability, and mobility in plants. This study is the first to use MSNs for manganese delivery in crops. MSN-encapsulated manganese (II, III) oxide nanoparticles (Mn_3O_4@MSNs) were applied to young, manganese-deficient tomato plants. Five days after treatment, Mn_3O_4@MSN-treated plants had 84% and 87% higher biomass than MSN-treated and Mn_3O_4-treated plants, respectively. Mn_3O_4@MSN-dosed leaves had an average photosynthetic efficiency (Fv/Fm) of 0.747, while other treatments and controls remained below 0.6. Fv/Fm below 0.74 in tomato plants indicates stress conditions. Mn_3O_4@MSNs had higher Mn translocation, with 37% of plant Mn content detected outside of the dosed leaves in Mn_3O_4@MSN-treated plants versus 23% for Mn_3O_4-treated plants. Mn mass in younger leaves in particular was 2.2 times higher with Mn_3O_4@MSN treatment than with Mn_3O_4. These results demonstrate that Mn_3O_4@MSNs are an effective solution for overcoming manganese deficiency in crops.

8.03.P-We008 Children At-Risk of Chronic Herbicide Exposure in the Agricultural Midwest

Elisa Jazan[1] (1)Tufts University

Background: Agricultural use of the herbicide 2,4-dichlorophenoxyacetic acid (2,4-D) is rapidly increasing in the United States, particularly in the Midwest, driven by weed resistance and reliance on genetically engineered crop systems that require intensive chemical inputs. Many other herbicides are applied concurrently with 2,4-D. Estimating non-occupational exposure is complex, but educational proximity to cropland suggests widespread chronic exposure for children who are a vulnerable population. Despite concerns, long-term health effects of low-level herbicide exposure remains limited and policy protections are weak.

Objectives: This work uses a geospatial approach to highlight potential chronic exposures for children in educational settings in Illinois.

Methods: Glyphosate, atrazine, 2,4-D, and total herbicide use on corn and soybeans (2016–2019) were evaluated at the school-district level; pesticide intensity and proximity (10 m and 500 m) were calculated for >4,000 public schools, stratified by proportion of surrounding cropland.

Results: From 2016–2019, pesticide use on corn and soybeans remained consistently high, with 14-19% of school districts composed of ≥75% cropland in Illinois and 34-43% in Iowa.

In Illinois nearly 1,800 public schools were within 500 m of farmland; of these, 194 had >50% cropland area within the buffer, with >61,500 students enrolled. At 10 m proximity, 138 schools had >50% cropland area and 34 had >80%. In Iowa about 850 public schools were within 500 m of farmland; of these, 104 had >50% cropland area within the buffer with >25,000 students enrolled. At 10 m proximity, 21 schools had >50% cropland area and 4 had >80%.

Conclusions: This geospatial analysis shows that children attending public schools throughout agricultural areas of Illinois are at risk of chronic exposure to herbicides Policy guidelines for spraying near educational facilities should be strengthened. This ecological study can be used to identify where to focus public health resources in order to protect children's health. Children's exposures to pesticides should be limited as much as possible.

8.03.P-We009 Development of a Free Program Analyzing PFAS in CT Farm Soils

Jasmine Jones[1] and Sara Nason[1] (1)Connecticut Agricultural Experiment Station

In May 2025, the Connecticut Agricultural Experiment Station (CAES) began accepting samples to test for per- and polyfluoroalkyl substances (PFAS) in Connecticut farm soils. PFAS are a group of emerging contaminants that are both highly toxic and pervasive in the environment. PFAS are a concern in CT farms due to the land-application of biosolid-based fertilizers and other soil amendments, prior to the PFAS-containing fertilizers and soil amendments ban in 2025. PFAS in soil has the potential to spread through groundwater to drinking wells and bioaccumulate in food crops, posing negative consequences for human and animal health. The goal of this program is to collect data that will be helpful in determining existing background levels locally, and for CT state agencies to develop guidelines that will balance public health with the impact to CT farmers and

agriculture. Since beginning the program, we have analyzed soil from both CAES field sites and several commercial farms. However, with the lack of regulations for PFAS in soil, the possible financial consequences of negative public perception of PFAS to farmers, and the inability to maintain participant confidentiality against Freedom of Information Act (FOIA) requests, participation in our program has been low. The limited results show that low levels of PFAS are widespread, but so far, the measured concentrations are within background levels determined in previous work. We continue to work to make our program impactful, to benefit the lives of CT residents.

8.03.P-We010 From Biosolids to Beef: Developing Diagnostic and Management Tools for PFAS-Impacted Agricultural System

Cheryl Murphy[1], A. Daniel Jones[1], Hui Li[1], Angel Abuelo[1], Jerad Jaborek[1], Barry Bradford[1], Lori Ivan[1], Sara Baustert[1], Efstathios Sarmikasoglou[1], Janet Hengesbach[1] and Jason Grostic[2] (1)Michigan State University, (2)Grostic Farms

Land application of municipal biosolids is widely used to recycle nutrients and organic matter back to agricultural soils. However, historical biosolids applications at a Michigan beef farm resulted in the introduction of per- and polyfluoroalkyl substances (PFAS) into the agricultural production system, creating challenges for livestock management, food production, and environmental sustainability. Following identification of contamination, a multidisciplinary research program was established to characterize PFAS movement through interconnected components of the farm system and develop practical approaches to reduce livestock exposure. Studies examined contaminant transfer from soils to forage crops, evaluated factors influencing livestock uptake, and assessed management strategies designed to reduce bioaccumulation. Particular emphasis was placed on developing diagnostic tools for agricultural decision-making, including evaluation of relationships between PFAS concentrations in blood and multiple muscle tissues to determine whether minimally invasive sampling approaches could be used to predict tissue burdens. Additional investigations examined the influence of animal housing and feeding practices on PFAS exposure and evaluated amendments intended to reduce contaminant bioavailability within agricultural soils. Results demonstrate how persistent contaminants introduced through residuals management practices can move through agricultural systems while also identifying opportunities to reduce exposure and support continued food production. The development of blood-based diagnostic approaches and farm-scale mitigation strategies provides practical tools for producers and regulators managing contaminated agricultural landscapes.
This case study illustrates the value of integrating environmental chemistry, exposure science, animal agriculture, and risk management to address emerging contaminants in food production systems. Lessons learned may inform future approaches to residuals management, agricultural sustainability, and contaminant mitigation in agricultural landscapes.

Disclaimer/Disclosure: Funded by Michigan Department of Agriculture and Rural Development and US EPA

Circularity Under Climate Change - Affects on Adaption, Resilience and Ecosystem Services

8.04.P-Tu015 Optimal Allocation of Biomass Across Utilization Pathways Using Techno-Economic and Climate Performance Metrics

Hamed Kouchaki-Penchah[1], Francis Lebreux Desilets[1], Daniel Liu[1], Lucas Moreau[2] and Milad Aghabararnejad[1] (1)CanmetENERGY, Natural Resources Canada, (2)Bureau du forestier en chef

Biomass is a limited renewable resource with multiple competing applications across different utilization pathways, creating challenges for its optimal and sustainable allocation. Conventional assessments often rely on static greenhouse gas (GHG) metrics and simplified system representations, which may not adequately capture the temporal dynamics of climate impacts or the role of biogenic carbon.

This study presents an integrated framework under development to evaluate biomass utilization pathways by combining techno-economic analysis with time-dependent climate impact assessment. A harmonized dataset of biomass conversion pathways has been compiled to enable consistent estimation of techno-economic performance across a range of technologies. In parallel, a dynamic modeling approach is being applied to link emission profiles to radiative forcing over extended time horizons, allowing characterization of both near-term and long-term climate effects.

The framework incorporates representations of biogenic carbon dynamics derived from forest management scenarios, enabling the construction of time-dependent emission profiles that reflect changes associated with biomass extraction and use. These profiles are combined with bioenergy conversion emissions and used to evaluate climate impacts over time.

To ensure meaningful comparisons, pathways are evaluated within groups defined by their primary end-use, maintaining functional consistency across technologies. Within each group, a multi-objective approach is applied in which levelized cost and cumulative radiative forcing are assessed jointly to identify pathways that represent optimal trade-offs between economic performance and climate impact.

This ongoing work aims to provide a transparent and flexible framework for evaluating biomass allocation strategies, with particular emphasis on the importance of temporal dynamics in climate assessment. The proposed approach supports lifecycle-based evaluation and contributes to more robust, decision-relevant insights for sustainable biomass utilization.

8.04.P-Tu016 A Circular Digital Cockpit Framework for Structured Decision Support in Circular Economy Assessments

Sonali PATEKAR[1], Bernard Yannou[1] and Michael Saidani[2] (1)CentraleSupélec, Université Paris-Saclay, (2)École de technologie supérieure

The transition to a circular economy (CE) requires moving beyond fragmented sustainability initiatives toward integrated, data-driven decision-making systems. Despite the rapid development of CE tools, indicators, and regulatory frameworks, organizations continue to face significant challenges in consistently operationalizing

these approaches across products, territories, and value chains. A persistent gap remains between data availability, indicator construction, decision-making processes, and the effective implementation of circular actions.

To address these limitations, this work introduces the Circular Digital Cockpit (CDC), a comprehensive decision-support framework designed to enhance the design, monitoring, and operationalization of circularity and sustainability performance within organizations. The CDC structures the assessment process into interconnected stages: system definition, data governance, indicator construction, performance evaluation, scenario generation, and the identification of priority actions. This unified modelling approach ensures coherence and traceability across the full decision-making chain.

The framework integrates established methodologies, including Life Cycle Assessment (LCA), diverse circular economy models, and Theory of Change, enabling the transformation of descriptive system data into actionable, decision-relevant insights. It is designed to facilitate the systematic comparison of circular strategies across heterogeneous contexts while maintaining methodological consistency.

The CDC is applied to multiple representative use cases spanning industrial and territorial systems. These include a telemanipulator from Manitou, the territorial system of the Paris-Saclay agglomeration, construction material reuse in collaboration with CSTB, and an MRI system from GE Healthcare focusing on spare-part reuse and end-of-life recovery. Across these systems of interest, different CE models function as computational engines within the CDC, enabling the exploration and comparison of alternative circularity strategies.

The primary contribution of this work lies in proposing an integrative modelling framework that bridges the gap between data, assessment, and action. By enhancing transparency, consistency, and usability, the Circular Digital Cockpit provides a dynamic and scalable tool to support informed decision-making in complex industrial and territorial applications.

Disclaimer/Disclosure: This research is carried out within the CircularIT Alliance, a research chair co-sponsored by
CentraleSupélec and SystemX. CircularIT partners are: Manitou Group, GE Healthcare, Mews Partners, Agglomération Paris-Saclay, SIOM, CSTB.

8.04.P-Tu017 A Novel Downscaling Framework for City-Level Household Environmental Impact Assessment To Support Urban Circular Economy Strategies

Paalo Moreno[1], Marianne Pedinotti-Castelle[2] and Ben Amor[1] (1)Interdisciplinary Research Laboratory on Sustainable Engineering and Ecodesign (LIRIDE), Department of Civil and Building Engineering, Université de Sherbrooke, Sherbrooke, Canada, (2)Ministère de l'Environnement et de la Lutte contre les changements climatiques, Ville de Québec, Canada

Applying circular economy strategies in an urban context requires an accurate city-level assessment of household environmental impacts, which account for the largest share of urban environmental burdens. However, current approaches typically rely on a single income-based scaling factor to downscale national estimates, overlooking the diversity of socioeconomic and demographic (SED) factors that shape spending

differently across consumption categories, potentially introducing systematic bias into inter-city comparisons. This study argues that no single SED factor universally captures variation in household expenditure across consumption categories, and that category-specific drivers can be systematically identified even under aggregate-data constraints. To address this, we developed a category-specific environmentally extended input-output analysis (EEIOA) downscaling framework that systematically compares SED factors as allocation parameters across consumption categories. The framework integrates expenditure differentiation based on confidence-interval overlap with inequality assessment using the Gini coefficient, enabling structured driver selection at household and per-capita levels. The framework is demonstrated using the OpenIO-Canada model and Quebec household expenditure statistics applied to five cities, with climate change as the impact indicator. Results show that no single SED factor drives expenditure variation: income drives only discretionary categories; household type leads essential and household-related categories; tenure drives transportation; and region size shows limited differentiation across categories. Uniform income scaling produces city-specific errors of up to 30%, systematically overestimating emissions in high-income cities and underestimating them in low-income ones, with an inter-city coefficient of variation that is two to three times higher than that of any driver-based approach, artificially amplifying perceived differences between cities. These findings demonstrate that category-specific driver selection is essential for accurate city-level environmental accounting, a prerequisite for designing effective urban circular economy strategies. Identifying category-specific drivers further enables targeted circular interventions toward the different SED subgroups. The framework is transferable to any region where SED factors disaggregate household expenditure statistics, adaptable to varying data availability.

8.04.P-Tu018 Closing the Loop on Sanitation: Container-Based Sanitation as a Circular Economy Approach to Reducing Waterway Contamination in Haiti

Jean Bernard Durone[1] and Sasha Kramer[2] (1)National Institute for Scientific Research (INRS), (2)Sustainable Organic Integrated Livelihoods (SOIL)

In low- and middle-income countries with limited wastewater infrastructure, untreated human waste is among the most pervasive yet under addressed sources of aquatic ecosystem contamination. Cap-Haitien, Haiti's second largest city, exemplifies this challenge acutely. Built on a coastal flood plain and crossed by the Haut-du-Cap River system, the city has no sewage or waste treatment infrastructure and has experienced recurring flood disasters that disperse waste from open defecation and unlined pit latrines across the landscape and into waterways. Conventional sanitation facilities compound the problem further, with latrines positioned directly over rivers and routinely emptied into nearby waterways. Flood risk is projected to intensify with climate change and sea-level rise, making source-based waste interception increasingly urgent.

Sustainable Organic Integrated Livelihoods (SOIL) operates a container-based sanitation (CBS) service across urban and peri-urban neighborhoods of Cap-Haitien, currently serving more than 30,000 people. Rather than allowing waste to enter waterways, SOIL's closed-loop model intercepts it at the source: sealed containers are regularly collected and transported to SOIL's treatment facility – the only waste treatment infrastructure in the region – where waste is converted into agricultural compost. In 2025, SOIL treated 1,050 tons of waste, producing over 250 tons of compost distributed to local farmers, agriculture programs, and reforestation initiatives, completing a full circular economy loop from waste collection to ecosystem restoration.

This presentation examines SOIL's circular economy CBS model, articulating the theory of change connecting service delivery to reduced environmental loading in a climate-vulnerable coastal watershed. We discuss system design, operational trade-offs, and conditions for replication in similarly resource-constrained contexts. SOIL's experience demonstrates that circular sanitation systems can simultaneously eliminate a major pollution source, strengthen climate resilience, and generate ecological co-benefits for underserved communities globally.

8.04.P-Tu019 Natural Hazard Resilience in LCA: A Framework Reconciling Simulation-Intensive Assessments With Stochastic LCA

Ben Amor[1] and Xavier Tanguay[1] (1)LIRIDE - Sherbrooke University

Natural hazards affect the sustainability of the built environment because of the environmental impacts tied to repairs and downtime. Asset performance assessments rely on simulation-intensive workflows to connect frequent and infrequent hazards with their expected damage and repair activities, enabling the estimation of associated environmental impacts through environmental life cycle assessment. However, processing large numbers of simulation inputs with LCA is cumbersome, let alone propagating uncertainty for the associated simulation. This project proposes a novel coupling framework that leverages a dual presampling strategy paired with a preaggregation step on background environmental datasets, expediting in minutes the computation of hundreds of thousands of stochastic LCA results. The coupling framework is applied through two case studies exploring the LCA of hurricane wind repairs for a 19-storey building and a portfolio of 127 buildings in Halifax, Canada. The large number of simulations supported by the coupling framework enables the estimation of the contributions from common and uncommon winds over the service life of the buildings, establishing a quantified baseline environmental “budget” towards resilience enhancements for the buildings. The 19-storey building results are primarily driven by the failures of the structural system that only happen following extremely rare events. Environmentally conscious resilience enhancements for this building are therefore constrained to a small budget and should primarily focus on structural enhancements. Conversely, the portfolio case study emphasizes that some neighborhood subsectors and specific buildings can overly contribute to the vulnerability of the portfolio, leading to an increased environmental budget in applying resilience enhancements. The case studies underline how the coupling framework can assist engineering-level and urban-scale decision-making in developing sustainable and resilient assets. The coupling framework and its underlying methodology aim to foster new developments in simulation-intensive assessments, paving the way towards optimizing mitigation and adaptation strategies in a climate change era.

Dealing with Fire: Post-Fire Monitoring to Assess Water Quality and Ecological Health

8.05.P-We215 Impacts of the 2025 Palisades Fire on Coastal Water Quality: The Critical Need for Human Health Risk Standards in Post-Wildfire Monitoring

Onja Davidson Raoelison[1], Annelisa E. Moe[2], Tania ineda-Enriquez[3], Naomi Meurice[2] and Kerry J. Nickols[2] (1)Stanford University, (2)Heal the Bay, (3)Natural History Museum of Los Angeles County

Wildfires are becoming more intense and frequent due to climate change, especially in urban areas where contaminants can reach coastal environments. In January 2025, the Palisades Fire destroyed over 6,800 structures, impacting the watershed and coastal ocean in Santa Monica Bay. This study aims to (1) evaluate

first-flush storm pollution, (2) analyze spatiotemporal contaminant trends in coastal water, and (3) assess health risks of fire-related contaminants. Ocean water was collected from January 22 to May 1, 2025, at 16 beach sites, including 9 within the burned area, and analyzed for 225 contaminants, including turbidity, bacteria, heavy metals, nutrients, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), per- and polyfluoroalkyl substances (PFAS), and volatile organic compounds (VOCs).
Burned sites exhibited elevated turbidity, bacteria, and heavy metals after the first storm, while PAHs and PCBs followed opposite trends. Time series analysis showed contaminants peaked on February 6th at Topanga County Beach. By May 1st, heavy metals were no longer detected in the burned area, while some PFAS appeared for the first time and nutrients remained elevated.
This study also identifies major gaps in post-fire coastal monitoring frameworks. The only established human health threshold for recreational water is for bacteria; for all other contaminants, we relied on EPA Regional Screening Levels (RSLs), the tool recommended by the Los Angeles Regional Water Board, in the absence of established health-based standards, yet only 64 of 225 contaminants had applicable RSLs. Several contaminants had detection limits exceeding those RSLs, resulting in inconclusive non-detect results.These findings highlight the urgent need for science-based post-fire coastal monitoring policies as wildfires increasingly threaten coastlines under climate change.

8.05.P-We216 Drinking and Surface Water Quality Impacts Following the 2025 Palisades and Eaton Fires

Christopher Olivares[1], Allison Tilzey[1], Lyssa Morgan[1], Joseph Allen[2] and Hannah Healy[2] (1)University of California, Irvine, (2)Harvard University

Urban and wildland-urban interface fires can impair both drinking water systems and stormwater by introducing and mobilizing chemicals from buildings, distribution systems, and legacy contamination sources. Following the 2025 Palisades and Eaton Fires in Los Angeles, we evaluated post-fire drinking water quality and studied the first-flush storm event in the Eaton Fire burned area. For drinking water, we sampled 53 homes in the three months following the fires to evaluate volatile organic compounds, disinfection by-products, and metals. Multiple volatile organic compounds (VOCs) were detected across the service area, including toluene, naphthalene, xylenes, and benzene, but most detections were below California maximum contaminant levels, with limited exceedances. Proactive distribution system testing and flushing was associated with low post-fire VOC levels. To characterize stormwater, we sampled the first precipitation event after the fires along a vertical transect within the Eaton Fire burn area. Fire-impacted sites exhibited elevated dissolved organic carbon, some metals, and per- and polyfluoroalkyl substance (PFAS), as well as adenosine triphosphate (ATP) levels as a proxy for overall microbial activity. These findings provide field-based chemical and microbial characterization of drinking water and stormwater risks following urban fires, which can be used for future monitoring and water safety policies after these fires.

8.05.P-We217 Using Non-Targeted Analysis and High-Resolution Mass Spectrometry To Identify Chemicals in Drinking Water Distribution Systems After Wildfires

Angela Batt[1], Eva Stebel[1], Yvonne Heaney[2], Dexter Adams[3], Shirley Pu[4] and Laura Brunelle[5] (1)U.S. Environmental Protection Agency, (2)California State Water Resources and Control Board, (3)ORISE fellow at U.S. Environmental Protection Agency, (4)Pegasus Technical Services, Inc., (5)Former ORISE fellow at U.S.

Environmental Protection Agency

Concerns have been raised over the impact of wildfires on drinking water quality degradation within distribution systems, which are the complex system of pipes that transport drinking water from a treatment plant to consumers' homes. Drinking water from distribution systems in multiple wildfire-impacted communities in California, including Santa Rosa (2017), the Camp Fire in Paradise, Northern California (2018), and Los Angeles (2025), have shown high levels of volatile organic compounds (VOCs), such as methylene chloride and benzene. Wildfires can cause thermal damage to service line materials, such as plastic pipes, and potentially introduce combustion products and contaminated water into the drinking water distribution system. The origin of the contamination in drinking water service lines is not always well understood, and standard targeted chemical analyses may not capture the full range of impurities. High-resolution mass spectrometry and non-targeted analysis (NTA) methods are being used to identify contaminants in drinking water collected from distribution systems impacted by wildfires in southern California. About 100 drinking water samples from a range of infrastructure types were collected from eight different distribution systems over a year-long timeframe. One-liter sample volumes were concentrated with solid phase extraction and analyzed using established NTA methods on an LC-Orbitrap. Targeted and suspect screening libraries are being used to identify known chemicals that may be present in samples, including about 2000 per- and polyfluoroalkyl substances (PFAS), pesticides, plasticizers, disinfection by-products, and other emerging contaminants. A comparison between reference sites to impacted distribution systems is being performed to prioritize chemical features for additional chemical identification, with the identification process using both experimental open-source and in-silico predicted reference spectra. This information will inform future targeted chemical measurements for improved monitoring and recovery response after fires.

General: Systems Approaches

8.06.P-Th186 Interactive Effects of Acid Deposition and Hydrological Shifts on Topsoil Biogeochemical and Microbial Functions

Minseok Park[1], Yonghwee Seo[1] and Seunghun Hyun[1] (1)Korea University

Acid deposition and climate change-driven hydrological shifts can simultaneously alter soil chemical and biological processes, yet their interactive effects remain poorly understood. This study evaluated the interactive effects on topsoil biogeochemistry and microbial functions using a controlled soil column experiment under simulated acid rain (pH 5.6 and 4.0) and alternating drought-flooding regimes consisting of 2-week drought and 48-hour flooding events. Soil chemical properties, nutrient availability, metal mobility, and metagenome-based microbial functional diversity were evaluated throughout the experiment. Results showed that the combined stressors decreased topsoil pH by 0.5-1.2 units and induced substantial fluctuations in redox potential (Eh) during flooding-to-drought transitions. Biogeochemical speciation and extraction analyses revealed that these chemical disturbances altered nutrient cycling, reducing dissolved and extractable carbon (C), nitrogen (N), and phosphorus (P) fractions by 15-30%. Concurrently, sequential extraction analyses demonstrated that intensified acidification and moisture fluctuations enhanced the mobility of potentially toxic metals, increasing water-soluble and exchangeable fractions by 20-40%. Partial Least Squares Path Modeling (PLS-PM) indicated that these chemical disturbances indirectly reduced soil microbial diversity through alterations in nutrient cycling and metal availability. These findings suggest that acid deposition and hydrological shifts act synergistically to

alter soil biogeochemistry and microbial functions, potentially compromising soil ecosystem resilience and biogeochemical functioning under future climate change.

Disclaimer/Disclosure: This study was supported by the Core Research Institute Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (NRF-2021R1A6A1A10045235).

8.06.P-Th187 Applying Bowtie Methodology in Industrial Hygiene To Strengthen the Management of Critical Controls in Order To Reduce Polycyclic Aromatic Hydrocarbons Exposure

Alexandra Duguay[1] (1)Rio Tinto

Bowtie approach is a globally recognized method for barrier-based risk management. It is widely used in high-risk industries such as the mining industry. As part of its comprehensive risk management uplift program, Rio Tinto now embeds Bowtie methodology for all its High and Very High consequence risks (Class III and IV in Rio Tinto's Risk Framework); this process has been recently adapted from Process Safety and Tailings risk management to other disciplines: ie Health, Community and Social Performance, Closure, Security and Environment. The output of the process is that every class III and IV risk is clearly mapped with all its potential causal factors and consequences displaying them out in a diagram shaped like a bowtie. It also enables systematic visualization of all controls, both preventative or mitigative in a manner that is clear and efficient for all levels of the organization including front line workers. This results in a powerful yet simple visual representation of all risk or hazard scenarios, facilitating the strategic implementation of measures required to control or minimize risk. It is a straightforward way to evaluate which controls are critical and which ones need improvements and how to assure control effectiveness. In this review, the methodology is applied to improve the management of controls in place to reduce exposures to Polycyclic Aromatic Hydrocarbons in several Rio Tinto Anode paste plants. Polycyclic Aromatic Hydrocarbons and more specifically Benzo (a) pyrene exposures are considered carcinogens and thus Class IV risks. We believe that applying the bowtie methodology will allow significant harmonization of current management of all controls and result in robust and consistent exposure reduction programs across the business.

General: Systems Approaches

8.06.V-01 Molecular and Morphological Assessment of Genetic Diversity in Nigerian Cocoyam Landraces for Conservation and Climate Adaptive Breeding

Nneka Emmanuel[1], Enyinnaya Emmanuel[1] and Mary Iwuagwu[1] (1)Abia State University

Crop genetic diversity is a critical yet undervalued component of global biodiversity, and its erosion threatens ecosystem resilience, food security, and sustainable agricultural systems. This study assessed the genetic diversity of 50 Nigerian cocoyam landraces (Colocasia esculenta and Xanthosoma sagittifolium) to support conservation prioritization and climate-adaptive breeding strategies. We hypothesized that Nigerian cocoyam landraces harbor substantial intraspecific genetic diversity that can be harnessed for sustainable crop improvement and biodiversity conservation. Twenty morphological traits and four simple sequence repeat

(SSR) primers were employed for phenotypic and molecular characterization, respectively. Frequency distribution and cluster analyses of phenotypic data were performed using SPSS Version 26.0, while molecular data were scored in binary format and analyzed using PowerMarker Version 3.25 to estimate genetic diversity indices and generate a dendrogram. Eighteen of the 20 morphological traits effectively discriminated among the landraces, producing two major phenotypic clusters. Molecular analysis resolved four major genetic clusters, with gene diversity values ranging from 0.59 to 0.76 (mean = 0.69) and a mean allele number of 8.25, indicating substantial intraspecific genetic variation among accessions. All four SSR primers successfully amplified across the 50 accessions, confirming their effectiveness for cocoyam germplasm characterization. The observed genetic variability highlights the potential of Nigerian cocoyam landraces as valuable genetic resources for conservation and climate-resilient breeding programs. Furthermore, this study demonstrates how molecular biodiversity assessment of underutilized tropical crops can contribute to environmentally sustainable agricultural systems by supporting resilient crop development, agroecosystem stability, and long-term food security within a One Health framework. These findings align with SETAC's objective of integrating biodiversity considerations into environmental sustainability and risk assessment.

Proactive by Design: Alternatives Assessment in a Changing Global Chemical Policy Landscape

8.08.T-02 Alternatives Assessment Codes of Practice

Romain Figuière[1], Steven Bennett[2], Niladri Basu[3], Charlotte Brody[4], Jodi Connell[4], Holly Davies[5], Peter Fantke[6], Kelly Grant[7], Molly Jacobs[8], Tom Lewandowski[9], Heather McKenney[10], Colleen McLoughlin[11], Cheri Peele[4] and Margaret Whittaker[12] (1)Stockholm University, (2)Household Consumer Products Association, (3)McGill University, (4)No Affiliation, (5)Washington State Department of Health, (6)Substitute ApS, (7)California Department of Toxic Substances Control (DTSC), (8)University of Massachusetts Lowell (UMass Lowell), (9)Gradient, (10)ChemFORWARD, (11)Enhesa, (12)ToxServices LLC

Realizing the full potential of alternatives assessment requires shared, scientifically rigorous expectations for how it is conducted. This presentation introduces the Alternatives Assessment Codes of Practice, a multi-sectoral effort to meet that need, organized around three tiers: a Purpose that defines the overarching goals and scope; Principles that establish the core tenets of any assessment; and Codes of Practice that define minimum requirements across six assessment domains, designated as "required" or "context-specific" based on assessment goals, decision context and constraints.

Alternatives assessment is an essential tool to support informed substitution of hazardous chemicals, and its relevance continues to grow. Across regulatory, commercial, and community contexts, green and sustainable chemistry goals, sustainable materials management strategies, and circular economy initiatives are driving demand for safer alternative chemicals, materials, and products. Yet expanded use of alternatives assessment has exposed challenges related to consistency, transparency, and quality. Without a shared starting point for what constitutes acceptable practice, assessments may vary widely in rigor and depth, raising concerns about the ability of alternatives assessment to consistently identify safer solutions while avoiding regrettable substitutions.

Over the last two decades, numerous alternatives assessment frameworks and guidance documents have been

developed, such as those issued by the Interstate Chemicals Clearinghouse and California Safer Consumer Products program, among others. Although these differ in scope and prescriptiveness, they evaluate alternatives across similar domains: hazard, exposure potential, performance, cost, and feasibility. Flexibility has been recognized as a defining feature of alternatives assessment given highly variable decision contexts, data availability, timelines, and resource constraints. Yet flexibility without clear expectations risks uneven implementation and inconsistent outcomes that compromise the goal of identifying safer, functional alternatives.

The presentation will discuss the conceptual foundation and envisioned structure of the Codes of Practice. This effort is being guided by an international, multi-sectoral technical committee representing government, industry, academia, and nongovernmental organizations. The anticipated publication date will be announced.

8.08.T-03 A Toxicity-Weighted Methodology To Evaluate the Sustainability of Mixtures: A Case Study on High Entropy Alloys

Julie Schoenung[1], Oladele Ogunseitan[2] and Seth Mehalic[1] (1)Texas A&M University, (2)University of California, Irvine

Sustainability assessment of complex materials such as mixtures and metallic alloys requires robust methodologies that appropriately distinguish between additive and non-additive material properties. Current approaches apply uniform weighted-average calculations across all sustainability criteria, which inadequately captures the complex, synergistic behaviors exhibited by toxicity and other non-additive indicators in mixtures, alloys, and other multi-component materials. This study develops and applies an improved methodology for criteria assessment in sustainability evaluation that explicitly distinguishes between additive criteria (e.g., cost, embodied energy) and non-additive criteria (e.g., human health damage, human and labor rights pressures). We introduce a toxicity-weighted scoring system that accounts for the disproportionate influence of highly toxic constituents through non-linear weighting functions, providing more realistic estimates than simple weighted averages while avoiding overly conservative worst-case assumptions. The methodology is applied to binary alloys (Fe-Ni, Fe-Mo), dilute alloys (Fe-based stainless steel, Ni-based superalloys), and various high entropy alloy compositions (transition metal, refractory, and light-weight systems). More specifically, human health damage scores for individual metallic elements, derived from a published dataset, are used to calculate alloy-level scores as a function of alloy composition. Results demonstrate that assessment methodology significantly influences materials selection options, with differences between the conventional and improved assessment methods ranging from 1 to 28 points (out of 100 possible points) in alloy-level human health damage scores. Alloying elements such as molybdenum and tantalum, with high individual elemental scores and known toxicity burdens, cause significant increases in alloy-level scores even when present in low concentrations. Interestingly, the reduction in nickel content from over 50% in superalloys to only 20% in high entropy alloys is advantageous due to nickel's known carcinogenicity. This framework advances sustainability-informed materials selection for complex multi-component systems where empirical data remain unavailable, with implications extending beyond high entropy alloys to other mixtures, formulations, compounds, and multi-material products.

Disclaimer/Disclosure: 9/9/2026 - Presenter change (from Julie Schoenung to Oladele Ogunseitan; co-author);

"no longer able to attend." (nmayo)

8.08.T-04 Implementing AI Workflows in Chemical Hazard Assessment: ChemFORWARD Data Trust Case Study

Gabrielle Rigutto[1], Heather McKenney[1], Chris Bartlett[1] and Grace Campbell[1] (1)ChemFORWARD

An estimated 350,000 chemicals are found in commerce, yet a very small fraction possess sufficient human and environmental hazard data to substantiate their safe use. Addressing the remaining data gaps through traditional in vivo and in vitro testing is both cost-prohibitive and time-intensive. Similarly, conducting comprehensive chemical hazard assessments (CHAs) through manual literature review and expert evaluation is bottlenecked by the same resource constraints. To accelerate this pipeline, artificial intelligence (AI) and machine learning (ML) models are emerging as potential tools for streamlining chemical hazard identification.

This session explores tactical implementations of AI workflows using ChemFORWARD's Chemical Hazard Data Trust ("Data Trust") as a framework for scaling safety insights while upholding scientific and data integrity. The Data Trust is a centralized, science-based tool designed for sharing peer-reviewed CHAs conducted by qualified toxicologists using standardized, GHS-aligned methodologies. Presenters will discuss how AI could optimize data-ingestion pipelines in CHA development, like automated literature synthesis, and predict specific toxicological endpoints for data-poor chemicals using ML-based Quantitative Structure-Toxicity Relationship (QSTR) models. This presentation will also detail how ChemFORWARD Data Trust could be leveraged to validate AI-based assessments. Additionally, presenters will explore where AI tools might support downstream data analytics, such as parsing raw ingredient data and gathering data insights for ChemFORWARD's Safer Chemistry Profiles (SCPs). SCPs assign Hazard Bands to ingredient lists provided by retailers, suppliers, and other interest groups using CHAs in the Data Trust. Finally, the presentation will address critical guardrails and outstanding challenges in predictive toxicology. While AI significantly reduces the burden of data acquisition and classification, human scientists remain critical in upholding scientific integrity and final decision-making.

8.08.T-05 Comparison of Publicly Available AI and Non-AI Tools To Search for Read-Across Surrogates

Jennifer Rutkiewicz[1] and Margaret Whittaker[1] (1)ToxServices LLC

Read-across is an approach that predicts the toxicity of a chemical using data on a structurally similar chemical on the basis that similar structures have similar toxicological profiles. This technique has gained acceptance for assessing data poor chemicals and filling data gaps with existing data, avoiding costly and time-consuming testing. A challenge with using read-across in a chemical hazard assessment is identifying a suitable surrogate in terms of structural similarity and data availability. This presentation exemplifies and compares four publicly available tools (Ambit2, PubChem, the United States Environmental Protection Agency (U.S. EPA) CompTox Dashboard, and the Organisation for Economic Co-operation and Development (OECD) QSAR Toolbox) and two Artificial Intelligence (AI)-based tools (Google AI and ChatGPT) in read-across applications and describes their strengths and weaknesses. The tools vary in the degree of expertise required to perform a search, with Ambit2, PubChem, and CompTox being relatively simple to use and QSAR Toolbox requiring more knowledge. However, QSAR Toolbox excels in identifying potential surrogates with relevant data. Ambit2 also

offers an option to filter matches based on data availability, whereas CompTox and PubChem may return large numbers of structures that require evaluation to determine if there are sufficient data available to fill gaps. The tools employ different similarity indices to identify related structures and vary in terms of identification of toxicologically relevant structures; regardless of the tool used, potential surrogates require evaluation by a toxicologist with consideration of functional groups of concern, size, toxicokinetics, and physicochemical properties. Finally, we have employed publicly available artificial intelligence (AI) platforms with mixed success. Compared to the non-AI tools that identify surrogates that are often data-poor based on quantitative measures of similarity, when prompted appropriately, the AI platforms identify a limited number of potential surrogates with consideration of data availability and factors impacting suitability. AI-generated outcomes require review to ensure accuracy and locate primary sources, but are helpful in the initial stages of surrogate selection. When combined with a toxicologist's expert judgment, the combined use of AI- and non-AI software tools comprises an effective preliminary approach to identify appropriate chemical surrogates.

8.08.T-06 Implementing Safer Alternatives to EDCs: Insights From Real-World Substitution

Molly Jacobs[1] and Joel Tickner[1] (1)University of Massachusetts Lowell (UMass Lowell)

The substitution of endocrine disrupting chemicals (EDCs) has become a growing priority for governments, businesses, and civil society organizations seeking to reduce hazardous chemical exposures and advance safer chemistry innovation. Yet relatively little attention has focused on lessons from practical, real-world substitution experience across supply chains and sectors.

This presentation examines four case studies involving the substitution of bisphenol A (BPA), di(2-ethylhexyl) phthalate (DEHP), and per- and polyfluoroalkyl substances (PFAS) across a range of products and applications, drawing on the perspectives of both alternative chemistry providers and the downstream manufacturers, brands, and users responsible for implementing substitutes commercially.

Drawing from company experience, stakeholder interviews, and publicly available literature, several cross-cutting lessons emerge. Successful substitution rarely followed a drop-in pathway: safer alternatives consistently required function-specific redesign, new production processes, and sometimes fundamental changes to how performance was defined. Civil society advocacy played a consistent initiating role — translating scientific evidence into market pressure and procurement criteria before regulatory frameworks caught up; where regulation followed, it reinforced and accelerated what advocacy had set in motion. The cases also reveal that standards, certifications, and procurement specifications are not neutral — they can entrench hazardous chemistries for decades even when alternatives exist. Despite endocrine disruption being a central driver for substitution, alternatives were evaluated primarily through restricted substance list conformance — an approach structurally inadequate for detecting endocrine activity or the hazard profiles of novel replacement chemistries — leaving the door open, in more than one case, to regrettable substitution.

By examining substitution from both alternative developer and adopter perspectives, this work aims to provide practical learnings to strengthen future efforts towards a transition to safer and more sustainable chemistries and products across sectors.

Disclaimer/Disclosure: Support for this project was provided by The Pew Charitable Trusts. The views expressed herein are those of the author(s) and do not necessarily reflect the views of The Pew Charitable Trusts.

Proactive by Design: Alternatives Assessment in a Changing Global Chemical Policy Landscape

8.08.P-Tu306 Defect Engineering Pathways for Sustainable Quantum Communication Chip Design

Sahar Shata[1] and Julie Schoenung[1] (1)Texas A&M University

Quantum communication is rapidly progressing toward scalable hardware deployment, yet sustainability considerations remain largely absent from early-stage quantum material and process design. Color centers in diamond, silicon carbide (SiC), hexagonal boron nitride (h-BN), gallium nitride (GaN), and zinc oxide (ZnO) are emerging solid-state qubit platforms for secure photonic communication. However, defect engineering pathways used to create optically active quantum states—including ion implantation, electron beam irradiation, femtosecond laser writing, and heteroepitaxial growth—introduce substantially different thermal, chemical, health, and economic burdens that become embedded into future manufacturing pathways.

Here, we construct cradle-to-gate inventories for twenty host crystals-defect engineering combinations and implement a multi-attribute sustainability assessment framework that integrates life cycle assessment (LCA), chemical hazard assessment (CHA), human health toxicity (HHT), and technoeconomic assessment (TEA). Results reveal a distinct performance-sustainability tradeoff across defect engineering pathways. Diamond pathways consistently exhibit the highest environmental, hazard, health, and economic burdens due to thermally intensive growth and chemically aggressive post-defect stabilization. In contract, SiC demonstrates a more balanced near-term pathway by retaining strong quantum communication functionality while moderating fabrication burdens, particularly under laser-writing routes. h-BN exhibits the most favorable sustainability profile, especially under femtosecond laser writing and heteroepitaxial pathways, owing to reduced thermal demand, simplified post-defect processing, and lower chemical intensity. GaN and ZnO exhibit selective lower-burden pathways but remain constrained by precursor-related tradeoffs.

This study demonstrates how early-stage sustainability screening can guide greener-by-design quantum communication technologies before manufacturing pathways become technologically locked-in. As sustainable product design and functional material cyclicity emerge as national research priorities, early-stage sustainability screening provides a pathway to reduce future manufacturing tradeoffs while enabling safer material and process selection.

8.08.P-Tu307 Hazard Beyond Mass: Rethinking Waste Assessment in Emerging Technologies

Sahar Shata[1] and Julie Schoenung[1] (1)Texas A&M University

Hazardous waste streams associated with e-waste, photovoltaic modules, PFAS-containing materials, medical

waste, and emerging quantum and AI technologies are becoming increasingly important sustainability and policy concerns. Beyond the challenges of packaging, storage, transportation, and disposal, these waste streams originate from upstream product-design decisions in which chemicals of concern are incorporated as functional materials to achieve targeted performance. As these materials become embedded into rapidly expanding technologies, end-of-life management increasingly reflects earlier material-selection choices and highlights the need for safer alternatives and hazard-informed product design strategies.

Current sustainability discussions frequently rely on waste mass as a surrogate for environmental concern. However, waste mass and hazard represent fundamentally different dimensions of waste. While mass reflects physical scale and infrastructure burden, hazard emerges from material composition, toxicity, persistence, mobility, bioaccumulation, and exposure pathways. Consequently, environmental and human-health impacts do not scale linearly with waste quantity, and low-mass waste streams may generate disproportionate hazard burdens. Likewise, hazard reduction may occur without waste mass reduction, demonstrating that waste quantity alone cannot adequately inform safer substitution or end-of-life risk management. We argue that contextual comparisons between emerging technology wastes and larger bulk waste streams, although useful for illustrating scale, become misleading when interpreted as evidence of low hazard relevance.

Using examples spanning photovoltaics, PFAS-containing materials, e-waste, medical waste, quantum technology, and AI infrastructure waste, we show that hazard pathways operate independently from mass pathways and therefore require multidimensional approaches that extend beyond binary hazardous/non-hazardous classifications. We propose a dual-framework approach that separates mass-oriented waste management from hazard-oriented governance using hazard-weighted metrics based on toxicity intensity, persistence, mobility, and propagation potential. Reframing waste assessment through hazard-informed and design-oriented metrics provides a more physically grounded framework for alternatives assessment, safer material selection, and early-stage sustainability-informed product design.

8.08.P-Tu308 Incorporating Endocrine Disruption Endpoints Into Business Decision-Making

Aly Lorenz[1], Alexis Tempkin[1], Heather McKenney[2] and Catherine Rudisill[3] (1)The Pew Charitable Trusts, (2)ChemFORWARD, (3)Safer Chemistry Advisory

Scientific advancement, regulatory action, and consumer awareness have increased attention on endocrine disrupting chemicals (EDCs) such as per- and polyfluoroalkyl substances, phthalates, and bisphenols. As companies face regulatory and market pressure to address EDCs, accessible tools that help private sector decision-makers quickly identify potential endocrine disruptors can reduce business risk, enable market leadership differentiation, and support market transitions toward safer alternatives that protect public health.

The Pew Charitable Trusts' safer chemicals project works to reduce Americans' exposure to harmful EDCs. While there are numerous avenues to reach this goal, incorporating endocrine disruption into chemical hazard and risk assessments, chemical of concern listings, and relevant certification programs is a foundational milestone that will accelerate industry action to phase out hazardous substances in favor of safer alternatives.

We will share insights on efforts to incorporate EDC criteria into various chemical hazard assessment programs,

such as operationalizing EDC guidance from the European Union under the Classification Labeling and Packaging program. We will also discuss opportunities to craft shared definitions, classifications, assessment approaches, and other elements with the goal of providing consistent signals to industry to support informed decision-making that protects public health.

8.08.P-Tu309 Application of the TPD-Seq Workflow To Support Transcriptomics-Based Chemical Screening

Krittika Mittal[1], Ke Xu[1], Samuel J. Rulli Jr.[2], Guangyan Zhou[1], Jianguo Xia[1], Jessica Head[1] and Niladri Basu[1] (1)McGill University, (2)QIAGEN

There is growing scientific and regulatory interest in transcriptomic points of departure (tPOD) values in chemical screening and risk assessment. We recently optimized the TPDseq workflow which integrates in vitro microplate-based exposures with commercially available RNAseq library preparation kits and a cloud-based bioinformatics platform (www.expressanalyst.ca) to calculate tPODs in an efficient manner. The TPDseq workflow has since been adapted and applied in a number of case studies, expanding from the initial in vitro method, tested with human Caco-2 and HepG2 cells, and rainbow trout gill cells (RTgill-W1), using cell lysates as the starting material, to include RNA isolated from rainbow trout and zebrafish embryos. Intended to be chemical-agnostic, the various case studies include 11 mixtures (extracts prepared from soil samples collected at electronic waste sites), 19 priority pesticides of concern to Canadian ecosystems, and a screening study of 42 chemicals (food-related, pharmaceutical, industrial and personal care) in both human and RTgill-W1 cell lines, and 30 additional chemicals with diverse properties and of environmental concern in both rainbow trout embryos and RTgill-W1 cells. Through these case studies, we have streamlined the library preparation workflow to be able to process up to 384 samples within two workdays. In addition, a smaller case study embedded within the larger 42 chemical screening study allowed us to test whether we could reduce the reaction volume two-fold and obtain consistent transcriptomic responses, thus reducing the cost of library preparation by ~40%. Collectively, we demonstrate the applicability of the TPDseq workflow to obtain high quality transcriptomic information, across various types of chemicals, providing not only mechanistic information but also quantitative tPODs that may be useful as thresholds to aid in chemical screening. Additionally, these case studies yield a comprehensive transcriptomic database that could provide useful insights into bioinformatics and data analysis questions as we aim to incorporate omics data into decision making. Ongoing efforts include similar case studies with different chemical classes such as metals, and poly aromatic hydrocarbons (PAHs). Future efforts include further expanding this workflow to additional cell lines, and model and non-model aquatic species including Daphnia magna.

Prospective and Spatiotemporal Environmental Assessment for Energy and Transportation Transitions

8.09.T-01 High-Resolution Urban GHG Accounting for Energy System Transitions: A Framework for Selecting Consistent Methodological Approaches

Arianne Provost-Savard[1] and Annie Levasseur[1] (1)University of Quebec

Due to their high concentration of population and economic activities, urban areas represent strategic

intervention points for the implementation of energy system transition strategies aimed at climate change mitigation. In the City of Montreal, for example, the stationary energy sector accounts for nearly half of territorial greenhouse gas (GHG) emissions, calling for a transition toward low-carbon alternatives. The selection and elaboration of the most relevant mitigation strategies must be supported by GHG accounting methodologies representing actual and prospective emission trajectories at high spatiotemporal resolution.
The selection of a GHG accounting approach among the multiple existing approaches (e.g., territorial, consumption-based, consequential), each involving distinct methodological choices, and its consistency with specific objectives (e.g., policy-making, elaboration of mitigation targets, identification of carbon leakage caused by a mitigation strategy) has not yet been extensively addressed in the urban GHG accounting community. Existing studies rarely justify the choice of the accounting method with respect to its compatibility with the specific objective(s) pursued.
The main objective of this study is therefore to provide a framework for city-level GHG accounting, orienting the selection of a coherent approach and guiding the interpretation of the results in terms of their significance for global GHG emission reduction.
The framework is applied to an urban energy transition scenario assessed at high spatiotemporal resolution, representing increased renewable energy production through the anaerobic digestion of organic waste in the city of Montreal, as part of the Montreal Carbon Map project.
Results indicate that territorial and attributional life-cycle assessment accounting approaches may overlook significant global emission variations induced by climate change mitigation strategies, particularly when representing sectors that rely heavily on energy or electricity mixes, or when modeling decisions that lead to market-mediated consequences, e.g., the substitution of energy production from non-renewable sources.
This framework provides a practical tool that guides practitioners in selecting a GHG accounting method that is internally coherent with the specific objectives pursued and that effectively supports global GHG emissions reduction.

Disclaimer/Disclosure: This research received funding from Fonds de recherche du Québec (https://doi.org/10.69777/2001950) and the NSERC — Natural Sciences and Engineering Research Council of Canada.

8.09.T-02 Spatiotemporal Life Cycle Assessment of Electricity Generation From Wind Energy

Mariam Hosny[1], Iyngaran Panchacharam[1] and Sarah Jordaan[1] (1)McGill University

Wind energy is predicted to grow the most significantly in Canada by reaching 70 GW in 2050 under the current measures scenario. While overall emissions will be reduced, the environmental impacts of transitioning to renewable energy are less examined and in need of investigation. Life cycle assessments (LCAs) of wind energy are not fully geospatially resolved due to differences in capacity factors (CFs), turbine sizes, and project infrastructure. CFs have been identified as the most impactful parameter in LCAs of electricity generation from wind energy, leading to the highest reduction in variability of the life cycle greenhouse gas emissions when harmonized. Thus, we calculated the CFs of each wind turbine in Canada using the Canadian wind turbine database and the energy yield calculator within the Global Wind Atlas. The CFs of approximately 6400 turbines commissioned up to 2019 had a range of 11.6% to 62.8% and peaked around 39%. We combine the individual CFs with wind turbine characteristics reported by government databases and life cycle inventories to

characterize embodied environmental impacts. Further supported by information sourced from over 200 environmental impact assessments and a geospatial analysis of project infrastructure, we estimate material requirements wind projects and supporting infrastructure for a comprehensive, geospatial life cycle assessment of wind power in Canada.

8.09.T-03 Incorporating Biogenic Carbon From Electricity Transmission Corridors Into the Carbon Footprint of Quebec's Hydroelectricity

Flavien CHABOD[1], Évelyne Thiffault[2], Jean-Francois Boucher[3] and Annie Levasseur[4] (1)École de Technologie Supérieure, (2)University of Laval, (3)University of Québec, (4)University of Quebec

Hydropower is a low-carbon electricity source with minimal direct greenhouse gas (GHG) emissions. However, accurately estimating its carbon footprint requires accounting for multiple sources of biogenic emissions associated with hydropower infrastructures, the quantification of which remains incomplete in the literature. The carbon footprint of electricity distributed in Québec was thus revised upward by 42%, from 24.3 (CIRAIG, 2014) to 34.5 gCO_2eq/kWh (Levasseur et al., 2021), following the integration of biogenic GHG emissions from hydroelectric reservoirs. Despite this progress, the impact of electricity transmission line corridors on forested lands has yet to be incorporated into carbon footprint assessments.

In Québec, hydroelectric generation sites are mostly located in northern regions, while consumption centers are concentrated in the south, necessitating an extensive transmission network. This network covers a total area of approximately 180 000 ha across 8 bioclimatic domains. It's ecological zones defined by climate and dominant vegetation that reflect the spatial heterogeneity of forest carbon stocks across the province, spanning from boreal to temperate ecosystems. Of this total area, approximately 110,000 ha consist of directly impacted forested lands, with additional edge forests subject to boundary effects.

This ongoing study aims to quantify the net biogenic carbon impact of transmission corridors on Québec's electricity carbon footprint through four components: (1) the net loss of carbon stocks due to deforestation at the time of line establishment; (2) the loss of potential carbon sequestration on deforested surfaces; (3) the partial compensation through edge effects in forests adjacent to the corridors; and (4) the integration of these fluxes into a dynamic carbon footprint framework that accounts for the temporal profile of emissions.

These fluxes, expressed in C/ha, are combined with impacted surface areas to yield a value in gCO_2eq/kWh that can be incorporated into existing carbon footprint estimates. The results will contribute to a more comprehensive quantification of the carbon footprint of Québec hydropower, with implications for national GHG inventories and decarbonization policies.

8.09.T-04 The Health Burden of Air Pollution From Fossil Fuel Use in Buildings in the United States

Jonathan Buonocore[1], Huy Tran[2], Manish Soni[2], Mary Willis[1], Kaylin Vrkljan[1], Sean Mueller[1], Brady Seals[3], Kipruto Kirwa[1], Mary Willis[1] and Saravanan Arunachalam[2] (1)Boston University School of Public Health, (2)University of North Carolina, (3)Stanford University

Fossil fuel use in buildings is a major contributor to air pollution and associated health burdens. Recent studies have estimated that exposures to ambient PM2.5 (particulate matter ≤ 2.5 μm) from fossil fuel use in buildings may be responsible for between 1,300 to 2,200. Prior assessments have been limited by coarse spatial resolution and have not fully accounted for the health impacts of co-emitted pollutants, including nitrogen dioxide (NO2)

and ozone (O3). Here, we estimated the health impacts of PM2.5, O3, and NO2 from fossil fuel use in buildings at high spatial resolution. We quantified these impacts in monetary terms using a novel air pollution health impact assessment platform that includes updated background health data and a revised method for characterizing air pollution-related asthma.
We first obtained estimates of air pollution emissions from residential buildings and commercial and institutional buildings (U.S. Environmental Protection Agency 2021 National Emissions Inventory) and simulated the effect of these emissions on outdoor air quality using the Community Multiscale Air Quality Model (CMAQ) version 5.4, instrumented with the Direct Decoupled Method (DDM). We used this framework to separately model the contributions of emissions from the use of gas, oil, and coal in two building types (residential and commercial/institutional) to air pollution and health impacts. We translated these exposure estimates into health burdens using BenMAPR, a geospatial information systems-based air pollution health impact assessment model in the R statistical programming language. Our latest version of BenMAPR contains key updates to: mortality data at the U.S. Census tract level, background incidence and prevalence for four different types of asthma symptoms and other health outcomes, a method that captures the incidence of asthma symptoms among children with existing asthma, and a method that estimates the incidence of asthma symptoms in people whose asthma is due to air pollution exposure.
We find that fossil fuel use in buildings in 2021 led to 15,000 deaths (95% CI: 8,700 – 20,000), 5.5 million asthma symptom days (95% CI: 0.1 million – 11 million) in children with pre-existing asthma, and 15,000 (95% CI: 6,000 – 22,000) children with newly diagnosed asthma. These newly diagnosed children had 4.4 million asthma symptom days (95% CI: 1.7 million – 6.4 million) within a year of diagnosis.

8.09.T-05 Life Cycle Assessment Framework Development for Medium- and Heavy-Duty Vehicles: Toward Harmonized Assessment of Freight Decarbonization Pathways

Hana Mohammadi[1], Akash Gondaliya[1], Qingshi Tu[2], Miyuru Kannangara[3], Matthew Erkhart[3] and Guillaume Imbleau Chagnon[3] (1)University of British Columbia, (2)University of British Columbia (UBC), (3)National Research Council Canada

Medium- and heavy-duty vehicles (Classes 5-8) are essential to freight movement but remain difficult to decarbonize because vehicle duty cycles, payloads, lifetimes, and refueling or charging systems differ substantially across applications. Battery-electric, hybrid-electric, fuel-cell electric, and conventional vehicles are increasingly compared using life cycle assessment, yet published results are difficult to interpret side by side because studies use different system boundaries, functional units, life cycle inventories, and energy-supply assumptions.
This study develops a harmonized cradle-to-grave life cycle assessment framework for medium- and heavy-duty vehicles to support transparent comparison of freight decarbonization pathways. More than 40 studies published between 2015 and 2025 were reviewed to identify recurring methodological choices, data gaps, and sources of variability. Vehicle production inventories were compiled from GREET, the Environment and Climate Change Canada Fuel Life Cycle Assessment Model, ecoinvent, and peer-reviewed literature to characterize major vehicle components, manufacturing processes, and assembly energy use. Vehicle operation was modeled using National Research Council Canada datasets for fuel and electricity consumption, maintenance, component replacement, and lifetime travel distance. End-of-life processes were represented through dismantling, recycling, material recovery, and disposal pathways.
The review indicates that life cycle global warming potential for battery-electric and fuel-cell electric vehicles

can vary by a factor of two to three depending on electricity-grid carbon intensity, hydrogen production pathway, and inventory assumptions. The proposed framework reduces these inconsistencies by applying freight-based functional units, standardized vehicle and lifetime assumptions, transparent process-based inventories, and region-specific energy modeling. This work provides a consistent basis for evaluating conventional and alternative-fuel medium- and heavy-duty vehicles and can help researchers, fleet operators, and policymakers identify when vehicle electrification, hydrogen, hybridization, or other pathways are most likely to deliver robust climate benefits.

Disclaimer/Disclosure: National Research Council Canada - Research Contract 1031816

8.09.T-06 A Modular Life Cycle Assessment Framework for Lithium-Ion Battery Recycling: Capturing Technological Variation and Comprehensive Environmental Impacts

Anna Donova[1] and Sarah Jordaan[1] (1)McGill University

The electrification of transportation is a critical mitigation strategy for decarbonization, driving rapid growth in lithium-ion battery (LIB) deployment worldwide. While LIBs are crucial for decarbonization, effective end-of-life strategies, such as recycling, are essential to mitigate e-waste challenges and ensure economic and environmental sustainability. Life cycle assessment (LCA) has been extensively applied in the literature to evaluate the impacts of LIB recycling. However, existing models tend to be overly simplistic, failing to capture technological variation, lacking flexibility for users to build custom process chains, and providing an incomplete picture of environmental impacts beyond emissions, overlooking impacts such as human toxicity, ecotoxicity, and acidification potential.

A review of 152 LIB recycling LCA studies (2020–2024) reveals critical transparency and data gaps. Fewer than half of studies explicitly report their assessed recycling chain, disaggregated process-level inventories are rare, industrial data is nearly absent, and preprocessing is systematically overlooked. Even within a single recycling technology, process configuration, preprocessing routes, energy demand, and material recovery yields can vary significantly. Current existing models use fixed recycling chains, limiting applicability across the diverse configurations found in industry.

This study develops a modular LCA framework for all three LIB recycling pathways (pyrometallurgical, hydrometallurgical, and direct recycling) implemented in Python. The model features a user-friendly interface enabling custom analysis of preprocessing and recycling chains, with granular and customizable process level life cycle inventories. Preliminary results for nine hydrometallurgical pathway combinations (three different recycling chains × three preprocessing routes) show global warming potential ranging from 3.74 to 7.74 kg CO_2-eq/kg spent NMC622 LIB and terrestrial acidification potential ranging from 0.0217 to 0.0436 kg SO_2-eq/kg spent LIB, demonstrating that recycling chain choice has a substantial effect on LCA outcomes. Detailed results across all pathways and supply chain scenarios will be presented at the conference. This research provides actionable insights for policymakers, recyclers, and recycling pathway researchers that are seeking robust, geographically relevant LCAs of representative LIB recycling systems.

Prospective and Spatiotemporal Environmental Assessment for Energy and Transportation Transitions

8.09.P-Tu311 Developing Land Use Inventories for Life Cycle Assessment of Electricity Generation

Sarah Jordaan[1] (1)McGill University

Life cycle inventories of the direct land area required by energy technologies have been limited to date. Research efforts have emphasized the development of impact assessment methods for land use in life cycle assessment, opening the need for systems-wide land use inventories to leverage such methods. This project focused on developing inventories for energy technologies in the U.S. portion of the Western Interconnection, including the fuel supply where applicable. The presentation will describe a series of collaborations published and under review from this initiative. The analyses involved deep learning models that quantified direct land use by solar PV, wind power, as well as coal- and gas-fired electricity by processing more than 500,000 images with a resolution of 1024 by 1024 for of ~800 solar farms, ~350 wind power projects, and > 100,000 natural gas production wells. A workflow was developed that combines deep learning, energy data, and geospatial analysis to quantify land transformation and power density. Coal-fired power and concentrating solar power were manually completed due to the smaller number of infrastructure elements and facilities (less than 50 for each unit process for both energy types). Progress to date will be discussed, noting future research efforts. The aim is to contribute large-scale inventories to support the advancement of land use-related impact categories in life cycle assessment.

8.09.P-Tu312 Mapping Montreal's Carbon Footprint: Dynamic GHG Scenarios for Urban Car Travel to 2050

Marianne Tollemer[1], Annie Levasseur[2] and Valériane Champagne Saint-Arnaud[3] (1)École de technologie supérieure, (2)University of Quebec, (3)Université Laval

Greenhouse gas (GHG) emissions from car travel in Montreal represent 24 % of total household emissions, making transportation the largest contributor to their inventory. With more than 13 billion vehicle-kilometers traveled each year on the island of Montreal, shifting transportation behaviors is one of the key levers for GHG mitigation. This presentation introduces dynamic GHG emissions scenarios for car travel in Montreal to 2050, developed as part of the Montreal Carbon map project, which aims to represent emissions at a fine spatial and temporal scale, in order to raise awareness among municipal stakeholders and citizens.
Methodologically, origin-destination surveys for the island of Montreal were used as the empirical baseline and projected into the future. The Global Protocol for Community-Scale Greenhouse Gas Inventories was applied using the induced activity method. Future vehicle-kilometers, fleet electrification, energy consumption, and the share of light trucks versus passenger cars are estimated through 2050. Theoretical maximum potentials are then compared against behavioral change literature to derive realistic scenarios.
Results show that behavior changes alone – assuming the entire population technically capable of shifting from car use to active modes (walking and biking), public transportation or carpooling did so – would have yielded approximately 20 % emission reductions in 2018 and 2023. Considering the effectiveness of behavior change interventions yields a much lower score than 20 %. In fact, according to several studies, it is rather 7 to 10% of the population targeted by behavioral change measures that would change their mode of transport, not the entire

population. Vehicle electrification alone would not meet the city's emissions reduction targets, yet could reduce emissions by 49 % by 2050 relative to 1990 under a moderated electrification scenario. Combined with full population-wide modal shift, a 61 % reduction is achievable.
These findings highlight electrification and modal shift as interdependent but insufficient-alone levers for deep urban decarbonization. By translating complex emission scenarios into fine-scale spatial and temporal representations, the framework supports both scientific understanding of urban decarbonization pathways and evidence-based decision-making.

Disclaimer/Disclosure: This study is part of the Carbon Map project for the city of Montreal, which is financed by Natural Sciences and Engineering Research Council of Canada, Fonds de recherche du Québec Nature et Technologie, Canada Research Chair on Measuring the Impact of Human Activities on Climate Change.

8.09.P-Tu313 Integrated Life Cycle Assessment and Costing of Lithium-Ion Batteries in Electric Vehicles: Incorporating Battery Degradation and End-of-Life Circularity Modelling

Yiwen Liu[1] and Sarah Jordaan[1] (1)McGill University

Electric vehicles (EVs) have emerged as a key technology for decarbonizing the transportation sector. Central to this transition are lithium-ion batteries (LIBs), which serve as the primary energy storage technology enabling vehicle electrification. However, the environmental and economic sustainability of EV LIBs across their full life cycle remains insufficiently investigated. Existing studies frequently rely on simplified assumptions for battery lifetime and degradation modelling, neglecting the influence of operational conditions on battery aging. Furthermore, most studies assess end-of-life (EOL) strategies in isolation, with limited attention to the interactions and trade-offs between multiple circularity pathways. Integrated life cycle assessment (LCA) and life cycle costing (LCC) frameworks that jointly evaluate the environmental and financial performance of EV LIBs remain scarce.

To address these persistent gaps, we develop an integrated LCA and LCC framework for EV LIBs incorporating dynamic degradation and EOL pathway modelling. A circularity model is developed to evaluate competing EOL strategies, including refurbishment, remanufacturing, reuse, repurposing, and alternative recycling technologies. Allocation approaches are investigated to distribute the associated environmental and economic burdens across the circular battery value chain. Furthermore, physics-informed semi-empirical degradation models are integrated to characterize battery aging behavior and estimate battery lifetime under first- and second-life operating conditions.

Preliminary results suggest that incorporating aging-aware lifetime estimation and interconnected circularity pathways may significantly influence the estimated environmental impacts and economic performance of EV battery systems, altering the relative performance of circularity strategies and the identification of key cost and impact drivers.

By addressing these long-standing gaps in use-phase degradation modelling and EOL circularity assessment, our work advances integrated LCC and LCA frameworks for EV LIBs and offers actionable insights for battery designers, fleet operators, and policymakers navigating trade-offs among EOL pathways. As EV adoption

accelerates globally, understanding the environmental and economic implications of EV batteries through detailed operational and EOL modelling is essential for supporting sustainable transportation planning and future battery supply chain decision-making.

Disclaimer/Disclosure: This research was supported by a master's scholarship from the Fonds de recherche du Québec – Nature et technologies (FRQNT) and partially supported by the NSERC Alliance Missions GHG Grant.

8.09.P-Tu314 Life Cycle Assessment of Electricity Generation in Canada: A Systematic Review and Meta-Analysis

Mariam Hosny[1], Maya Dwivedi-Leng[1] and Sarah Jordaan[1] (1)McGill University

Understanding the life cycle impacts of electricity generation is critical to the achievement of environmental sustainability goals, such as grid decarbonization, transportation electrification, and net zero emissions. Life cycle assessments (LCAs) are challenged by the high spatial and temporal variability of the operations of the electric sector, particularly that LCA historically focused on impacts at a particular instant in a specific location. We conducted a systematic review of literature published from 2010 to 2025 to: (i) identify studies that complete LCAs of existing generation assets in Canada (coal, natural gas, oil, nuclear, biomass, hydropower, solar, and wind); (ii) determine gaps in the electricity generation technologies by a comparison to existing assets and Ecoinvent database in each province and territory; (iii) examine how LCAs accounted for spatiotemporal variability of assets, and (iv) complete a harmonization and meta-analysis of existing results. Around 65% of the studies were conducted in Ontario and Alberta, with the remaining LCAs performed in Quebec (13%), Saskatchewan (13%), and British Columbia (9%), while no LCAs were carried out in the remaining five provinces and three territories. Biomass was the most investigated fuel type, studied in around 48% of the identified articles, followed by coal, which appeared in 39% of the studies, whereas nuclear and oil were the least examined fuels, analyzed in 13% and 4% of the LCAs, respectively. Approximately 22 out of 23 LCAs evaluated the global warming potential, whereas the remaining impact categories were analyzed in only around 57% of the investigated articles. To clarify central tendencies and variability across LCAs, a harmonization and meta-analysis will present the harmonized environmental impacts of each electricity generation source. Results inform a detailed synthesis of research and areas in need of future research, while providing a harmonized dataset based on published LCAs.

5. Environmental (Human and Ecological) Risk Assessment

Advances in Bioaccumulation Science and Assessment: From Mechanisms to Predictive Tools

5.01.T-01 Bioconcentration of Pharmaceuticals in Aquatic Invertebrates Exposed to Complex Chemical Mixtures: Implications for Mixture Toxicology and Risk Assessment

Omotayo Sindiku[1], Stina Jansson[1], Daniel Cerveny[2], Tomas Brodin[2], Eva Weidemann[1] and Jerker Berglund Fick[1] (1)Umeå University, (2)Swedish University of Agricultural Sciences (SLU)

Pharmaceuticals are widespread micropollutants in freshwater ecosystems, co-occurring as complex mixtures rather than isolated substances. Despite extensive single-compound bioconcentration data, the influence of mixture complexity on pharmaceutical bioconcentration in aquatic invertebrates remains largely unexplored. Bioconcentration factors (BCFs) from single-compound exposures may not accurately represent realistic multi-contaminant conditions. This study investigated the bioconcentration of three widely detected pharmaceuticals; diclofenac (DCF; log K_ow 4.51), carbamazepine (CBZ; log K_ow 2.45), and trimethoprim (TMP, log K_ow 0.91) in damselflies (Odonata: Zygoptera), dragonflies (Odonata: Anisoptera), and caddisflies (Trichoptera). Organism were exposed under controlled laboratory conditions to four exposure types: mix132 (132 chemicals, n=6), mix80 (80 chemicals, n=3), mix5 (5 chemicals, n=3), and individual compound exposures (n=3), all an environmental relevant concentration of 200 ng/L. Following exposure, samples were analyzed using LC-MS/MS and BCFs were calculated as the ratio of tissue to water concentration. CBZ exhibited the highest BCFs across all species (10.42–57.34), consistent with its moderate hydrophobicity and limited biotransformation potential. Despite its higher log Kow, DCF showed low BCFs (0.65–9.83), likely due to ionization reducing membrane permeability. TMP displayed high variability (0.55–40.52), particularly in caddisflies. Caddisflies showed the highest BCFs overall, while dragonflies showed the lowest, highlighting pronounced species-specific differences. A consistent trend was observed across all species and compounds; BCFs were generally lowest under the complete mixture and increased progressively; individual > mix5 > mix80 > mix132. This pattern suggests that mixture complexity reduces uptake of individual compounds, potentially through competitive interactions at membrane transporters or altered partitioning behavior among co-solutes. High variability within exposure groups, especially for CBZ in the mix132 (caddisflies: 37.14 ± 17.49), indicates that physiological variation and organism life stage may influence bioconcentration. These findings challenge the direct extrapolation of single-compound BCFs to mixture-exposed environments and support the development of mixture-informed bioconcentration models for aquatic risk assessment of emerging contaminants.

5.01.T-02 Bioconcentration and Biotransformation of Structurally Diverse per- and Polyfluoroalkyl Substances in Aquatic Biota

Ian Mundy[1], Will Backe[1], Jesse Conklin[2], Sarah Kadlec[1] and Kevin Lott[1] (1)U.S. Environmental Protection Agency (US EPA), (2)Oak Ridge Institute for Science and Education (ORISE)

Due to the broad diversity of per- and polyfluoroalkyl substances (PFAS), techniques to predict the hazards of untested or data-poor structures are a key requirement for ecological risk assessment. To support such efforts, our group determined 7-day, sublethal median effect concentrations (EC50s) for diverse PFAS structures in

several model aquatic species to establish patterns among toxicity, chemical structure, and taxa. To understand the role of bioaccumulation and in vivo biotransformation in toxicity, whole-body bioconcentration factors (BCFs) were measured concurrently with EC50s, and tissues were screened for suspected metabolites. Tested species include two aquatic invertebrates, Hyalella azteca (amphipod) and Chironomus dilutus (midge), and a fish (Pimephales promelas; fathead minnow). The BCFs for commonly studied PFASs such as the perfluoroalkyl sulfonates (PFSAs) and perfluoroalkyl carboxylates (PFCAs) increase in a log-linear manner with perfluorinated carbon chain length. Much of the differences in toxicity among these PFASs can also be attributed to differential bioaccumulation, with a relatively consistent body burden predicted at the EC50 (critical body burden; CBB) for PFSAs and PFCAs of varying chain lengths. However, screening of more diverse structures (e.g., perfluorinated biphosphinic acids, fluorotelomer betaines) in midge shows that perfluorinated carbon chain length and other commonly used chemical properties such as octanol-water partitioning are poor predictors of bioaccumulation for those classes. While CBBs of these PFASs are generally consistent with PFSAs and PFCAs, more sophisticated techniques are required to model their uptake from the water column and predict EC50s. Further empirical data across a sufficiently diverse structural domain are needed to parameterize such models. Metabolite screening has also revealed substantial biotransformation of "precursor" PFASs such as the perfluoroalkyl sulfonamides (FASAs) and their N-alkyl derivatives. For example, preliminary data show the formation of equivalent perfluoroalkyl sulfinic acids and PFSAs from the C6 and C8 FASAs in fathead minnow. Work is ongoing to evaluate the impact this biotransformation may have on measured BCFs and EC50s. The presented work will highlight key findings in PFAS bioaccumulation and biotransformation relevant to modelling efforts and hazard prediction.

Disclaimer/Disclosure: The contents of this abstract neither constitute, nor necessarily reflect US EPA policy.

5.01.T-03 In Vitro Biotransformation of Organic Chemicals: Species Comparison of Mallard Duck and Double-Crested Cormorant

Matthew Schultz[1], Markus Brinkmann[1], Christy Morrissey[1], Michelle Embry[2] and Robert Letcher[3] (1)University of Saskatchewan, (2)HESI Global, (3)Environment and Climate Change Canada (ECCC)

Birds have historically been impacted by persistent organic pollutants which bioaccumulate and biomagnify; however, bioaccumulation is usually assessed with a bioconcentration factor (BCF) in aquatic species that cannot be readily extrapolated to air-breathing organisms. Using newer in vitro approaches, bioaccumulation can be assessed using substrate depletion methods to estimate the tissue-specific biotransformation rate of a chemical, and extrapolate to whole-body outcomes. Such methods, including the Organisation for Economic Co-operation and Development (OECD) Testing Guideline 319, have been validated in fish, with limited exploration into avian species. Direct, physiological measurements of biotransformation are critical to improving predictive models of bioaccumulation, and represent a data-gap in current toxicokinetics. The present study adapts these methods to birds, using mallard duck and double-crested cormorant as model species for comparison of adaptation and method development. Primary hepatocytes and sub-cellular fractions (S9) were isolated and cryopreserved from mallard duck and cormorant to investigate species-specific differences in biotransformation, using pyrene and 4-n-nonylphenol as benchmark metabolic substrates. Performance criteria including cell yield, viability, and metabolic activity were assessed to establish the robustness of isolation and cryopreservation methods. High-performance liquid-chromatography (HPLC) with fluorescence detection was utilized to measure chemical depletion of parent compounds over time. In vitro intrinsic clearance rates varied

between species (4.82 and 3.39 mL/hr/10^6 cells for pyrene in duck and cormorant respectively), with a similar trend observed in nonylphenol (2.51 and 1.31 mL/hr/10^6 cells). This study demonstrates the direct adaptation of TG 319 methods to birds, including wild bird species not typically included in standardized testing guidelines.

5.01.T-04 Building Better Bioaccumulation Assessments: Integrating Data, Models, and Tools

Jon Arnot[1], Alessandro Sangion[1], Liisa Toose[1], Trevor Brown[1], Pippa Curtis-Jackson[2], Steph Jones[2] and Michelle Embry[3] (1)Arnot Research & Consulting (ARC), (2)Environment Agency United Kingdom, (3)HESI Global

Assessing bioaccumulation (B) remains challenging because measured data are often limited, and all assessment metrics and methods have strengths, limitations, and inherent uncertainty. Current screening approaches commonly rely on octanol–water (KOW) and octanol–air (KOA) partition ratios as surrogates for partitioning to biological phases. While octanol is an effective biopartitioning surrogate for many hydrophobic neutral organic chemicals, its applicability to ionizable organic chemicals (IOCs), including perfluorinated alkyl acids (PFAAs), is more limited. At the same time, efforts to reduce or eliminate animal testing have accelerated the development of new approach methods (NAMs) based on in vitro and in silico approaches, which require continued evaluation and data generation. In vitro methods include fish S9 and hepatocyte assays for estimating biotransformation rates (OECD TG 319A/B), which can be integrated with in vitro–in vivo extrapolation (IVIVE) and one-compartment physiologically based biokinetic (1Co-PBK) mass balance models to calculate bioaccumulation metrics. In silico methods include quantitative structure–activity relationships (QSARs) for predicting bioaccumulation metrics and toxicokinetic parameters, such as whole-body biotransformation half-lives (HLB). This presentation provides an overview of recently developed databases, methods, and tools that support decision-making, including: (i) a weight-of-evidence approach aligned with OECD guidance and implemented in the Bioaccumulation Assessment Tool (BAT); (ii) the Bioaccumulation Evaluation Tool (BET) for calculating B metrics in aquatic and air-breathing organisms under laboratory and field conditions using in vivo, in vitro, and in silico data; (iii) the OECD Integrated Approach to Testing and Assessment (IATA) for bioaccumulation; (iv) new models for predicting KOW and KOA; (v) new biopartitioning databases and polyparameter linear free energy relationships (PP-LFERs) for estimating partitioning to storage lipids, membrane lipids, structural proteins, and serum albumin; and (vi) updated IVIVE models for applying S9 and hepatocyte data to parameterize 1Co-PBK models. Case studies highlight potential future IATAs for biopartitioning and biotransformation rate assessment which are key areas of uncertainty identified within the scientific community.

5.01.T-05 Descriptor-Based Prediction of per- and Polyfluoroalkyl Substance (PFAS) Tissue Accumulation Integrating Biomimetic Chromatography and Meta-Analysis

Carla Ng[1], Qianwei Li[1], Boris Droz[2] and Jennifer Field[2] (1)University of Pittsburgh, (2)Oregon State University

The tissue-specific bioaccumulation of per- and polyfluoroalkyl substances (PFAS) is directly associated with their toxic effects, as it controls the internal dose at the site of specific receptor interactions. Transitioning from in vivo chemical assessment to new approach methods (NAMs) requires understanding how toxicokinetics drive distribution from cells to whole organisms, essential for interpreting in vitro results. Models that translate

receptor- and cell-based assay data into organism-level predictions are therefore key to advancing NAM-based risk assessment. This work focuses on compiling available PFAS tissue distribution data and training predictive descriptor-based models. Data on PFAS tissue distribution are highly heterogeneous, deriving from single- or repeated-dose studies, and include studies of multiple species and sexes, with sampling intervals spanning minutes to weeks. Therefore, leveraging these data to construct useful predictive models is a complex task. To address this challenge, we compiled a meta-analysis database for 70 PFAS across mouse and rat tissues, comprising 8926 data points from 101 studies published from 1975 to 2026. We focused on rodent data, the most abundant PFAS tissue distribution data available. We first evaluated the performance of large language models (LLMs) to conduct risk of bias assessment using a randomly selected subset of studies, then applied the best-performing prompt-LLM combination to evaluate all studies for inclusion in the database. We examined a suite of pharmacokinetic parameters as candidate endpoints for harmonizing data across studies, including maximum observed concentration, area under the curve (AUC)-based tissue-to-plasma distribution coefficients, and single time-point measurements. The most representative harmonization strategy was selected based on biological relevance, data coverage, and internal consistency. Using the resulting harmonized dataset, we developed and evaluated a suite of machine learning models to predict tissue-specific PFAS distribution informed by biomimetic chromatography descriptors reported in our prior work. These descriptors characterize PFAS interactions with phospholipid membranes, serum albumin, and alpha-1-acid glycoprotein, three biological phases central to PFAS partitioning behavior. This work provides a practical, experimentally grounded framework to predict tissue-level PFAS accumulation, supporting risk assessment and evaluation of emerging PFAS.

5.01.T-06 Predicting and Validating Neutral and Anionic PFAS Bioconcentration and Partitioning to Environmental Systems Using Abraham ppLFERS Estimated From COSMOtherm Solvation Energies

Dominic Di Toro[1], Anthony Sigman-Lowery[1] and Olga Dmitrenko[1] (1)University of Delaware

Predicting Bioconcentration Factors (BCFs) are presently the focus of multiple approaches. However, accurate prediction of BCFs, particularly for chemicals that are partially or fully ionized at environmentally relevant pHs, remains a significant challenge. Traditional BCF prediction methods relied on estimated chemical hydrophobicity, measured by log KOW of the neutral molecule. However, this approach fails for PFAS or chemicals that are negatively charged anions at environmentally relevant pHs since electrostatic interactions are important in water. The Abraham poly-parameter Linear Free Energy Relationship (ppLFER) has been used to fit experimental BCF of neutral chemicals. This requires that the chemical's ppLFER parameters are available from other studies, for example organic solvents–water partitioning. For anionic chemicals, ppLFER partition coefficients exist for only a few specialized chemicals, such as carboxylic acid anions. We have developed a method that can estimate both chemical and solvent-water system parameters for neutral and anionic chemicals. We use the solvent-water partition coefficients estimated by the chemical thermodynamic program COSMOtherm and a multiple parameter nonlinear regression method. Reliable parameter estimates of the chemical and solvent regression parameters require a large dataset. We have initially employed 90 solvents and over 500 chemicals to estimate both the ppLFER parameters for neutral and anionic species, including carboxylic, sulfonic, amides and fluorotelomers PFAS. The resulting ppLFERs have been compared to experimental solvent-water partition coefficients for neutral chemicals resulting in root mean squared errors in the 0.4 to 0.6 range We will also present the initial results of our BCF ppLFER using experimentally measured

BCF for midge Chironomus dilutus, amphipod Hyalella azteca, and fathead minnow Pimephales promelas. An important part of the model is accounting for the fact that at the pH of the experiments, the partitioning of both the PFAS neutral and anion need to be considered since the neutral species are hydrophobic whereas the anion are more hydrophilic. The proportion of anionic and neutral chemical in solution are determined using pKa values calculated using a pKa model based on COSMOtherm solvation energies that we have developed.

Disclaimer/Disclosure: Supported by SERDP ER22-3175 Measuring and Predicting the Aquatic Toxicity of PFAS Mixtures Associated with AFFF

Advances in Bioaccumulation Science and Assessment: From Mechanisms to Predictive Tools

5.01.P-We059 Exploring Inter-Species Differences in Biotransformation Rates Using In Vitro, In Vivo and In Silico Data

Jon Arnot[1], Alessandro Sangion[1], Aaron Redman[2] and Michelle Embry[3] (1)Arnot Research & Consulting (ARC), (2)Exxon Mobil, (3)HESI Global

Toxicokinetics (TK) describes chemical absorption, distribution, biotransformation (metabolism), and excretion processes and rates. Reliable TK data are required for bioaccumulation and exposure assessment, interspecies extrapolation of toxicity data, and as part of in vitro-in vivo extrapolation (IVIVE) for the application of bioactivity data from New Approach Methods (NAMs) in a risk-based context. Thousands of chemicals require hazard, exposure, and risk evaluation for human and ecosystem health and there is a recognized need to reduce, replace, and refine animal testing. High quality TK data are essential for these assessments, yet in vivo TK data for a diverse range of speices are extremely limited and costly to generate, presenting a major obtacle and source of uncertainty in chemical evaluations. For many organic chemicals the biotransformation rate constant, or half-life (HLB), is a key determinant of the overal total elimination half-life (HLT). There is a pressing need to obtain reliable biotransformation rate data for a range of species for chemical safety and sustainability and to support biodiversity objectives; however, similarities and differences in biotransformation rates and HLB across species and estimation methods are poorly understood. Furthermore, because measuring biotransformation rates for all chemicals and species is not feasible, NAMs including in vitro, IVIVE models, and in silico approaches, are needed. This research includes the compilation, critical evaluation, and comparison of biotransformation rate data across species (e.g., fish, rodents, and humans) using in vivo, in vitro, and in silico (i.e., Quantitative Structure-Activity Relationship, QSAR) approaches. More than 22,500 in vitro biotransformation rates from hepatocyte, liver microsomal and liver S9 bioassays from human, rat, mouse and fish were compiled and critically evaluated for data quality. Approximately 680 new in vivo HLB estimates for rodents were calculated from critically evaluated HLT data in this study. Existing in vivo HLB estimates for humans (~913 chemicals) and fish (~628 chemicals) were included for the data comparisons. Existing OECD validated HLB-QSARs derived from in vivo data for humans (n=5) and fish (n=6) were also used in the comparisons. This work forms the basis for an Integrated Approach to Testing and Assessment (IATA) to systematiaclly address uncertainty in biotransformation rates and interspecies extrapolation.

5.01.P-We060 Advancing and Evaluating In Vitro-In Vivo Extrapolation for In Vitro Biotransformation Rate Data To Support Bioaccumulation Assessment

Liisa Toose[1], Alessandro Sangion[1], Jon Arnot[1] and Michelle Embry[2] (1)Arnot Research & Consulting (ARC), (2)HESI Global

There is a recognized need to develop and evaluate new approach methods (NAMs) to reduce, replace and refine animal testing to support chemical hazard and risk assessment. The Organization for Economic Cooperation and Development (OECD) has developed standardized testing guidelines (TG) for measuring in vitro biotransformation rates using rainbow trout hepatocytes (OECD TG 319A) and liver S9 homogenates (OECD TG 319B). In vitro-in vivo extrapolation (IVIVE) models are required to use these data to parameterize mass balance models for calculating bioconcentration factors (BCFs). Recent advancements in IVIVE and BCF models were consolidated into "state-of-the-science" spreadsheet tools to calculate BCFs from S9 and hepatocyte in vitro tests for neutral and ionizable organic chemicals (IOCs). The new in silico tools are summarized providing transparent and standardized conditions for the calculations. The performance of the new models is evaluated through the compilation and critical evaluation of in vitro biotransformation rate data and in vivo BCF data in fish. A new in vitro biotransformation rate database with 1502 entries for 335 chemicals in fish developed from a review of over 70 scientific papers and reports is summarized. There are reliable quality in vitro and in vivo BCF data for 82 chemicals, and these data are used to evaluate the model performance. The results show a Type II bioaccumulation categorization error rate of about 5% when using in vitro data. Recommendations to further improve and evaluate IVIVE-BCF models are outlined. Additionally, these IVIVE updates are being integrated into a revision of the OECD 280 Guidance Document on determination of in vitro intrinsic clearance and extrapolation to in vivo intrinsic clearance.

5.01.P-We061 A Metric for Contaminant Carrying Capacity in Traded Food and Feed

Elsai Mati Asefa[1] and Frank Wania[1] (1)University of Toronto

International food trade can redistribute chemical exposure by moving contaminated commodities from production regions to distant consumers. Existing trade-linked exposure studies typically estimate contaminant transfer as the product of the mass of traded food and the measured or modeled residue concentration. This is necessary for exposure assessment, but it does not distinguish source contamination from the intrinsic capacity of different food matrices to acquire, retain, and transport chemicals. We propose a thermodynamically based food-transfer-potential metric to quantify this carrying capacity, defined as the product of a food's fugacity capacity Zfood and its traded volume, Vfood. Having units of mol Pa-1, Zfood Vfood represents the contaminant amount that a food can carry at unit fugacity. We derive Zfood Vfood for the major traded food and feed commodities. Bulk food Z-values are calculated from food composition and a compound's partitioning into storage lipid, membrane lipid, protein, water, carbohydrate, and other non-lipid organic matter. Vfood and its variability over time are derived from international trade data. Because partitioning, and therefore Zfood, can be readily predicted from molecular structure, the approach is applicable to any organic chemical present in traded food and feed items. Actual contaminant mass transfer can then be expressed as ZfoodVfoodffood, where ffood is the chemical fugacity in the commodity at origin, estimated from residue measurements or fate and food-chain models. Zfood Vfood values can be compared between compounds, revealing distinct trade-embedded transfers of chemicals with widely divergent partitioning properties, such as polychlorinated biphenyls, bisphenol A, and per- and polyfluoroalkyl substances. Similarly, Zfood Vfood values can be readily

compared between different traded commodities (e.g., seafood, major agricultural crops, livestock) and different food components (e.g., lipids, carbohydrates). Zfood Vfood provides a thermodynamic screening metric for identifying high-capacity food and feed commodities, trade routes, and chemical-matrix combinations that warrant monitoring or higher-tier exposure modeling. Importantly, a global-scale Zfood Vfood dataset will be a key building block to any effort trying to account for the global trade in food and feed in the assessments of exposure to any organic contaminant.

5.01.P-We062 Evidence for Trophic Dilution of Cyclic Volatile Methylsiloxanes in Aquatic Food Webs

Jaeshin Kim[1], Wataru Naito[2], Yuichi Iwasaki[2], Satoshi Ushioka[3] and Noriyuki Meguriya[4] (1)Dow Chemical Company, (2)National Institute of Advanced Industrial Science and Technology, (3)Environmental Control Center Co., LTD.,, (4)Silicone Industry Association of Japan

Bioaccumulation can be evaluated using several metrics, including the trophic magnification factor (TMF), which is a field-based measure particularly relevant for hydrophobic, lipophilic compounds where dietary uptake is the primary route of chemical exposure in aquatic organisms. Reported field TMFs of cyclic volatile methylsiloxanes (cVMS), however, vary widely (D4: 0.081-1.4, D5: 0.1-3.1, D6: 0.04-2.7), largely due to spatial exposure gradients from point sources and sampling bias. Because these ranges span the criterion value of 1, field studies have yielded mixed conclusions, indicating both trophic dilution (TMF <1) and trophic magnification (TMF >1).
This study evaluated TMFs of cVMS at two Japanese sites with minimal exposure gradients: the Yugawara coast and Lake Kasumigaura. Concentrations of D4, D5, D6, and two reference polychlorinated biphenyls (PCB 153 and PCB 180 which are non-metabolizable compounds) were measured in biota and sediments to determine field TMFs. In parallel, the Multibox AQUAWEB model was employed to predict biota concentrations and TMFs for the food webs in the study locations.
For Yugawara food webs, both measured and modeled TMFs of cVMS were consistently below 1, with strong ($p < 0.05$) or moderate ($p = 0.05$-0.10) statistical significance, indicating trophic dilution. In contrast, measured and modeled TMFs for PCBs exceeded 1 with strong statistical significance, confirming trophic magnification. For Lake Kasumigaura, all three cVMS exhibited trophic dilution (TMF <1) with moderate to strong statistical significance, whereas the reference PCBs showed clear trophic magnification (TMF >1).
Overall, this study provides additional evidence that cVMS undergo trophic dilution in both marine and freshwater food webs under conditions of no or mild exposure gradients, likely reflecting greater metabolic transformation compared with non-metabolizable reference compounds.

5.01.P-We063 Transgressing the Planetary Boundary for Novel Entities: Simulating a World Avoided by Regulating Toxic Chemicals

Chengkang Chen[1], Ziqi Zhang[1], Li Li[2] and Frank Wania[1] (1)University of Toronto, (2)University of Nevada Reno

Scientific and regulatory efforts have been taken in the past 60 years to tackle chemical pollution. Evaluating the benefits and efficacy of chemical regulation is essential for convincing society of the necessity of such efforts. We revisit the history of global contamination with persistent organic pollutants by constructing a counterfactual scenario of polychlorinated biphenyl (PCB) production and use in the absence of control

measures. Global emissions, environmental burdens, human exposures, and health hazards in this "world avoided" estimated using a mechanistic modelling framework are contrasted with the "historically observed" scenario. Without control measures, we estimate that (i) global PCB emissions from 1930 to 2025 would have been 6-fold higher, (ii) the global environmental PCB burden would have been 7-fold higher by 2025, with less industrialized and polar regions experiencing a larger difference than industrialized regions, and (iii) human exposure to PCBs would have been 34-fold higher by 2025, exceeding health safety threshold for at least 40% of the human population. While subject to many assumptions and uncertainties, the analysis highlights that national and global regulatory measures targeting persistent organic pollutants have prevented the transgression of a planetary boundary for novel entities. Simulations of the global risks posed by toxic chemicals under different regulatory scenarios can inform the delineation of the safe operating space.

5.01.P-We064 Considerations for Implementation of the OECD 319A: Determination of In Vitro Intrinsic Clearance Using Cryopreserved Rainbow Trout Hepatocytes (RT-HEP)

Sarah McCoy[1], Joshua Arnie[1], Anson Browne[1] and Glenn Sneckenberger[1] (1)Eurofins EAG Agroscience

The OECD 319A assay offers a practical alternative to live-fish testing and supports in-vitro to in-vivo extrapolation for bioaccumulation assessment by measuring hepatic biotransformation in rainbow trout hepatocytes. Demonstrating technical competency in this assay requires evidence that the test system is metabolically active, analytically robust, and reproducible. In this work, pyrene was evaluated as a positive control to establish laboratory proficiency in running the OECD 319 assay and to confirm expected substrate depletion performance under routine single tube and multi-tube assay conditions. Pyrene was selected as it is a well-characterized substrate for fish hepatic biotransformation, was the selected reference chemical during ring-test trials and has been used as a model compound in studies examining intrinsic clearance and extrapolation to in vivo metabolism. Assay performance was evaluated using control acceptance criteria based on OECD 319 guidance and multi-laboratory ring-test. Evaluation metrics included measurable parental depletion over time, adequate signal intensity across the sampling interval, and high inter-assay reproducibility. Considerations were made for impacts of test vessel material, sampling time points, volatility of the test solution and a single tube versus multi-tube test design. Test design and the test vessel material had measurable impacts on analytical consistency, however the results demonstrated consistent pyrene turnover within the target analytical window, indicating metabolic competence of the cryopreserved hepatocytes and suitability of the analytical method for kinetic evaluation. These findings support the use of pyrene as a fit-for-purpose positive control for laboratory implementation of OECD 319 and provide a practical framework for demonstrating readiness to generate reliable intrinsic clearance data for regulatory and screening applications.

5.01.P-We065 Toxicokinetic Differences Between Dermal and Oral Exposure to Ultraviolet Absorbers

Ruosi Li[1], Haitao Shen[2], Jing Zhan[1], Bing Lyu[3], Jingguang Li[3] and Jiaying Liu[1] (1)China Agricultural University, (2)Zhejiang Provincial Center for Disease Control and Prevention, (3)China National Center for Food Safety Risk Assessment

Ultraviolet absorbers (UVAs) are a group of emerging contaminants with high-production volumes and widespread use in sun screens and food contact materials. Dermal and oral exposures are generally regarded as the main human exposure pathways, but pathway-specific toxicokinetics of UVAs were still unclear. Here,

pathway-specific toxicokinetics of 5 typical UVAs were investigated using animal administration experiments and consecutively collected 24-hrs human urine. Unlike other UVAs, 2-Ethylhexyl p-methoxycinnamate exhibits a significantly longer biological elimination half-life and a larger volume of distribution following oral administration compared to dermal exposure, suggesting a potentially higher risk via the oral pathway. 2-(2H-Benzotriazol-2-yl)-4,6-ditertpentylphenol (UV-328) showed the greatest bioaccumulation, but limited systematic absorption and restricted tissue distribution for both pathways. It indicated entrapment of UV-328 in the enterohepatic circulation, which was also supported by its high lipophilicity and low metabolic rate. The oxidative metabolite of UV-328 was found to be an indicative of oral exposure. Further monitoring of 24-hrs human urine (n=220 from 16 participants) shows that non-oral exposure is probably the main exposure pathway for UV-328 in general population. In summary, this study addresses a key gap in understanding pathway-specific toxicokinetics of UVAs, and provides valuable data to improve the accuracy of assessing systemic exposure levels from multiple pathways.

5.01.P-We066 Implementing OECD Test Guideline 321: Practical Experience From a Hyalella azteca Bioconcentration Study

Elizabeth Ostermann[1] and Suzanne Schneider[1] (1)Eurofins EAG Agroscience Services, LLC

Bioaccumulation testing is a critical component of environmental hazard and risk assessment for chemicals. Fish-based studies have historically been used to generate regulatory bioconcentration data; however, OECD Test Guideline 321, the Hyalella azteca Bioconcentration Test (HYBIT), was adopted in 2024 as a non-vertebrate alternative for assessing bioconcentration in aquatic environments. In October 2024, ECHA (European Chemicals Agency) announced that HYBIT would serve as the standard information requirement under REACH, where applicable. Utilizing the HYBIT assay represents an important step toward reducing vertebrate testing.

To assess the practical implementation of this newly adopted guideline in a contract research organization (CRO) laboratory, we conducted a bioconcentration study according to OECD 321 and evaluated key operational considerations, methodological challenges, and lessons learned during study execution. This work provides an applied perspective on the feasibility of HYBIT in a routine testing environment and may help inform laboratories preparing to adopt the assay.

Advances in the Ecotoxicology and Risk Assessment of Per- and Polyfluoroalkyl Substances

5.02.T.A-01 Field Evaluation of PFAS Bioaccumulation in Benthic and Pelagic Organisms at Freshwater and Marine Sites

Elizabeth Nichols[1], Rachel Zajac-Fay[1], Jason Conder[1], Nicholas Hayman[2], Molly Colvin[2], Josiah Discar[2] and Anita Thapalia[3] (1)Geosyntec Consultants, Inc., (2)Naval Information Warfare Center Pacific (NIWC Pacific), (3)Exxon Mobil

The bioaccumulation of per- and polyfluoroalkyl substances (PFAS) in aquatic species has been widely documented and has implications for risk-management practices at aqueous film forming foam (AFFF) sites

where detectable PFAS is present. This presentation will discuss the results of two field studies conducted at a marine aquatic site and a freshwater aquatic site. Studies included 14-day in situ bioaccumulation tests with pelagic bivalves (freshwater Corbicula fluminea, saltwater Mytilus galloprovinciallis) and benthic annelids (freshwater Lumbriculus variegatus, saltwater Nephtys caecoides) alongside measurement of freely-dissolved concentrations (Cfree) using passive samplers in surface water and sediment. At the freshwater site, perfluoroalkyl sulfonic acids (PFSAs), especially PFOS, were the predominant PFAS detected in both abiotic media and biota. At the marine site, concentrations of PFAS were generally orders of magnitude lower. Perfluoroalkyl carboxylic acids (PFCAs), especially PFOA and PFHxA, were dominant in most saltwater site media, aside from benthic invertebrates, where PFSAs were more prevalent. The contrasting PFAS profiles between the sites are likely attributed to differing AFFFs as well as disparate environmental transport routes from release locations to the aquatic sample stations. Concentrations of PFAS in benthic invertebrates were approximately 3 to 20 times higher (on average) than concentrations in co-located pelagic invertebrates at both sites. This was primarily due to higher bioaccumulation by annelids compared to bivalves. For example, at the freshwater site, average PFOS bioaccumulation factors (BAFs) for benthic invertebrates (calculated using concentrations in annelids and sediment Cfree) were approximately 16 times higher than BAFs for pelagic invertebrates (calculated using concentrations in bivalves and surface water Cfree). Concentrations of PFAS in freshwater biota were approximately an order of magnitude higher than concentrations in marine biota; this was primarily due to higher abiotic concentrations at the freshwater site. However, benthic and pelagic BAFs for most PFAS were generally an order of magnitude higher at the saltwater site, suggesting higher bioaccumulation potential for marine invertebrates or higher bioaccumulation rates when Cfree is lower. Overall, this data provides several general conclusions useful for evaluating bioaccumulation of PFAS by aquatic life.

5.02.T.A-02 Risk Characterization of PFAS in Estuarine Ecosystems

Marie DeLorenzo[1], Peter Key[2], Katy Chung[2], Paul Pennington[2] and Emily Pisarski[3] (1)National Oceanic and Atmospheric Administration (NOAA), (2)National Oceanic and Atmospheric Administration (NOAA), (3)National Centers for Coastal Ocean Science (NCCOS)

Estuarine ecosystems are vulnerable to pollution impacts from upstream riverine sources and adjacent urban inputs. Unique physico-chemical properties of estuaries such as salinity gradients, tidal dynamics and high organic carbon loading influence the bioavailability, bioaccumulation, and transport of chemical contaminants. Per- and polyfluoroalkyl substances (PFAS) are widely distributed in coastal environments, and understanding the potential for exposure and effects from these persistent organic pollutants is critical to safeguarding marine and estuarine resources. We integrated environmental PFAS distribution data, laboratory derived PFAS effects thresholds for estuarine species, and mesocosm level fate and effects data to identify the PFAS compounds most likely to occur in estuarine environments, the likelihood of negative impacts to estuarine species, and the modifying factors that influence PFAS risk assessment. Early life stages of estuarine species have lower thresholds of PFAS toxicity than adult forms. For seven PFAS tested with five estuarine organisms, toxicity was found to be both species and compound specific. Acute larval LC50 thresholds varied over 200-fold across compounds for the same species, and 13,000-fold across species for the same PFAS compound. PFAS toxicity increased with temperature, and decreased with salinity, but was not affected by UV light. PFOS was found to rapidly partition into estuarine sediments and animal tissues, compared to PFOA which persisted longer in the water column but was more readily taken up by benthic invertebrates. Fish generally exhibited lower sensitivity

than crustaceans. Larval invertebrates such as clams, snails, amphipods, and copepods were some of the most sensitive taxa. Toxicity thresholds were above environmentally detected PFAS levels, but in some cases were below the saltwater aquatic life criteria. Results of the probabilistic assessment may be used to prioritize PFAS for monitoring and remediation in estuaries.

5.02.T.A-03 The Mixture Toxicity of PFAS to Marine Aquatic Life Follows Additivity

Zacharias Pandelides[1], Nicholas Hayman[2], Molly Colvin[2], Jason Magnuson[1], Jennifer Arblaster[1] and Jason Conder[1] (1)Geosyntec Consultants, Inc., (2)Naval Information Warfare Center Pacific (NIWC Pacific)

Per- and polyfluoroalkyl substances (PFAS) are frequently detected in marine and estuarine environments, where organisms are typically exposed to mixtures rather than single compounds. To evaluate whether PFAS mixture effects can be predicted from individual-PFAS toxicity, this study measured the chronic toxicity of selected PFAS mixtures in marine aquatic life (mysid shrimp (americamysis bahia), and pacific topsmelt (Atherinops affinis)). Test organisms were exposed to indicator PFAS (PFOA, PFDA, PFHxS, and PFOS) in equitoxic mixtures in water as well as two mixtures representative of aqueous film forming foam sites (PFCA- and PFSA-dominant mixes of 10 PFAS) under controlled laboratory conditions. Across the mixtures tested, observed effects were generally consistent with additive behavior (e.g. LC50 in toxic units (± SD) for mysid shrimp for the three mixtures were 1.4 (1.2 to 1.5), 0.99 (0.73 to 1.3), and 0.63 (0.59 to 0.68)), indicating that combined toxicity could be reasonably predicted (LC50s in TUs are approximately 1) from the summed contributions of the four indicator PFAS. There was little evidence for strong synergistic interactions, although some mixtures showed species- and endpoint-specific deviations from strict additivity. These findings support the use of additive mixture frameworks in marine ecological risk assessment of PFAS, particularly at AFFF sites where exposure to multiple PFAS co-occur.

5.02.T.A-04 PFAS Bioaccumulation Factors Derived for Fish in an Economically Important River Basin

Frannie Nilsen[1], Kallie Davis[1], Jeff Deberardinis[1], Jared Wilson[1] and Kyle Rachels[2] (1)North Carolina Department of Environmental Quality (DEQ), (2)North Carolina Wildlife Resources Commission (WRC)

In North Carolina (NC), a known point source of PFAS contamination discharges into the Cape Fear River—a waterway over 300 kilometers long that serves as an essential drinking water source for NC residents and is heavily used by both commercial and recreational anglers. As a result, the river contains a distinctive mixture of emerging and legacy PFAS compounds. Since several of the detected PFAS are specific to this facility, many questions remain about their toxicity, environmental accumulation, and the impacts of exposure on both wildlife and surrounding communities.

To address some of these knowledge gaps, our study evaluated PFAS accumulation in fillets from the most frequently caught fish species in the Cape Fear River. Over 250 fish representing 14 species were collected along the river, from locations downstream of the point source to the Atlantic Ocean. Fillets were analyzed alongside in situ water samples for 56 different PFAS to support calculations of bioaccumulation factors (BAFs).

BAFs were derived for several PFAS across the 14 fish species, but PFAS signatures varied among species. This variation highlights differences in how PFAS of different sizes accumulate across the food web, suggesting that foraging strategy and diet may influence PFAS uptake. The resulting BAFs were paired with reference

doses (RfDs) to inform the NC Department of Environmental Quality's development of water quality standards aimed at protecting public health and state water resources. In parallel, PFAS concentrations measured in fish tissue were used by the NCDHHS to support the development of PFAS specific fish consumption advisories. Overall, the data generated through this study have informed multiple ongoing efforts at NCDHHS and NCDEQ and provide a comprehensive dataset that can support additional PFAS-related fish studies both within and beyond North Carolina.

5.02.T.A-05 PFAS Disrupt Immune and Neural Function Through Shared Cellular Mechanisms Across Species

Luisa Nunziangeli[1], Davide Rotondo[2], Davide Gualandris[2], Danae Zareifi[3], Konstantinos Papavasileiou[3], Antonio Calisi[2], Iseult Lynch[4], Antreas Afantitis[3], Greta Immobile Molaro[1] and Francesco Dondero[2]
(1)Genomics, Genetics and Biology Innovation Hub (Polo GGB), (2)Department of Science and Technological Innovation, University of Eastern Piedmont "Avogadro", 15121 Alessandria, (3)Novamechanics Ltd, (4)University of Birmingham

Per- and polyfluoroalkyl substances (PFAS) are ubiquitous contaminants whose ecological and human health risk assessment is challenged by chemical heterogeneity and limited cross-species mechanistic evidence. We integrated field ecotoxicology, controlled invertebrate exposure, and human cellular assays to dissect how PFAS — legacy long-chain and replacement chemistries — propagate through ecosystems and converge on shared cellular targets.

Fieldwork at the AFFF-impacted Albäck firefighting site (Trelleborg, Sweden) quantified 16 PFAS in soil, water, plants, and 35 invertebrate taxa, covering long-chain legacy (PFOS, PFOA, PFNA) and short-chain replacement (PFBA, PFBS, PFHxA, PFHxS, PFPeA, 4:2-FTS) classes. BCF, BSAF and TMF metrics revealed ecosystem-specific dynamics, with substantial bioaccumulation for both long- and short-chain congeners — PFAS persistence in food webs extends beyond long-chain compounds.

In E. fetida exposed 28 days to Trelleborg soils, tissue burdens correlated with neurotransmitter alterations (choline/glutamate depletion, adrenaline accumulation) and behavioral changes. Innate immunity was affected in parallel: phenol oxidase declined progressively across the gradient in coelomocytes and whole-tissue extracts, and CCF-1 and lysenin transcripts were altered. A separate 29-PFAS exposure (in vivo + in vitro) further modulated lysenin hemolytic activity, engaging both neural and immune effectors in the same sentinel.

We then profiled the 29-PFAS panel (legacy + ether-based replacements) on two human receptor axes. PFAS broadly engaged PPARα: most activated HEK293T reporters (~50-fold range, HFPO-DA highest), and reporter-negative compounds (PFUnA, 8:2 Cl-PFESA) induced PPARα-target gene programs. In human PBMCs (innate LPS 24h, adaptive PHA 72h), mixed-model analysis revealed cytokine-specific PPARα modulation (interaction $p<0.001$ adaptive arm). Structure-activity decomposition (chain length, end-group, ether-oxygens, branching) explained 13.4% of cytokine variance versus 5.5% for PPARα alone, with branching as the most FDR-robust driver ($q<0.05$). On the GABA-A axis, patch-clamp in human neuroblastoma cells with GABAergic activity showed pronounced reversible inhibition of GABA-evoked currents by long-chain legacy PFAS and selected short-chain replacements.

Bioaccumulation and conserved neural/immune signatures from sentinel to human models support chemistry-resolved hazard prediction for both PFAS classes.

Disclaimer/Disclosure: This project has received funding from the European Union's Horizon 2020 research

and innovation program under grant agreement No. 101037509 (SCENARIOS project).

5.02.T.A-06 Impact of Developmental Exposure to Environmentally Relevant Concentrations of per- and Polyfluoroalkyl Substances and Mixtures on Multi-Tissue Transcriptomic Profiles in Adult Zebrafish

Alyssa Meyers[1], Danielle Meyer[1], Alex Haimbaugh[2], Mackenzie Connell[1], Brianna Vo[1], Ashley Guarino[1], Emma Cavaneau[1], Grace Winny[1], Chia-Chen Wu[2] and Tracie Baker[1] (1)University of Florida, (2)Wayne State University

Concerns over the potential effects of per- and polyfluoroalkyl substances (PFAS) commonly present in the environment have risen since the early 2000s. Although certain PFAS, including perfluorosulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) are no longer used in manufacturing in the United States, they are ubiquitous in the environment due to their strong carbon fluorine bonds rendering them effectively indestructible. These PFAS may then bioaccumulate in sediment, water, and aquatic organisms. Harmful effects have been documented in both humans and aquatic wildlife including reproductive toxicity, immune suppression, and developmental disorders. However, the adult-onset effects of developmental exposure to PFAS on adults or relevant mixtures has gone understudied. The current study sought to determine the effect of an environmentally relevant levels of exposure of PFOA (70ng/L), PFOS (240 ng/L), and a mixture of each on larval zebrafish that were then raised to adulthood. Zebrafish are an important animal model, due to their genetic similarity, that can inform not only potential effect in human populations but also serve as a model for toxicity in aquatic vertebrates. RNA-Seq transcriptomic analyses was then used to analyze extracted RNA from brain, gonad, liver, and kidney tissue. Comparisons between larval and adult-onset differential gene expression, revealed significantly higher effects later in life. Analysis of differentially expressed genes revealed significant enrichment of several disease pathways including cancer, lipid metabolism disruption, endocrine disruption, organismal survival, and reproduction in PFAS exposed fish. Outcomes were found to be highly elevated in the mixture exposure. Early life PFAS exposure at environmentally relevant levels was found to have multisystemic effects months after initial exposure. Several potential mechanisms of toxicity were identified including CYP19A1 in the brain and PPAR in liver and kidney, potentially leading to the diseases observed. This research advances determination of mechanisms and effects of PFAS on public health, wildlife, and may be applied to regulating safe levels of PFAS in drinking water.

Advances in the Ecotoxicology and Risk Assessment of Per- and Polyfluoroalkyl Substances

5.02.P-We268 Analytical Methods and Data Uses for Total PFAS in Risk Assessment

Jennifer Arblaster[1], Jason Conder[1], Zacharias Pandelides[1], Anita Thapalia[2] and Anna Argyridou[2] (1)Geosyntec Consultants, Inc., (2)Exxon Mobil

Evaluation of the risks of per- and polyfluoroalkyl substances (PFAS) in the environment using methods that attempt to quantify total mass of PFAS, primarily using currently available analytical techniques that quantify organofluorine (OF) in environmental samples, have limitations. Predicting the risk of PFAS using an approach based on the total mass of OF does not allow for accurate hazard identification under risk assessment paradigms and therefore should not be used to support site-specific risk assessments at PFAS sites. This is because the

toxicity of any given PFAS is highly dependent on its particular chemical structure given all the PFAS do not pose same toxic effects. Simply put – a higher concentration of total PFAS (as measured using quantification of OFs) does not necessarily equate with higher PFAS exposure, hazard, or risk. As PFAS analytical chemistry, toxicology, and risk assessment knowledge continues to advance our understanding of the best approaches for evaluating PFAS at sites, we recommend that PFAS risk-based evaluations focus on PFAS that can be quantified individually using an "indicator chemical" approach. This paradigm has been well established to evaluate the risks of other compound classes (e.g., PAHs) that are unable to be completely quantified in environmental samples and/or lack compound-specific toxicity information.

5.02.P-We269 Beyond Transport: Low-Dose Short-Chain PFAS Modify Cell Migration, Barrier Integrity, and Invasion in Human Cell-Based Models

Gracen Collier[1] and Ramon Lavado[1] (1)Baylor University

PFAS are fluorinated hydrocarbons used in the manufacturing of commercial products which are consistently detected in both the environment and the US population due to their widespread use and resistance to degradation. While much research focuses on legacy PFAS, recent work on the impact of human relevant low-dose exposure to the short-chain PFAS still commonly used in the US has indicated their ability to alter the gene and protein expression of ABC membrane transport proteins critical to the movement of endogenous substrates and common medications throughout the body. Many of these same ABC proteins are involved in cell-cell interactions through membrane transport as well as through regulation of cell migration, tight junction formation, and invasion. However, short-chain PFAS have not been evaluated for their impacts to such cellular interactions. We aim here to determine the broader cell-cell impacts of 48-hour exposure to 1nM and 1µM PFBS, PFHxA, PFHxS, or 6:2FTOH in-vitro on the overall functionality of endogenous ABC transporters, cell migration, cell-cell junction integrity, and cell invasion in commonly used human cell lines, utilizing a novel transport assay, scratch assays, TEER, and cell invasion transwell inserts. Results indicate the ability of low dose short chain PFAS to increase ABC substrate efflux in HepaRG liver cells, with all 1nM and 1µM exposures significantly decreasing the retention of cholesterol (DMSO (1.00±0.08), 1nM: PFBS (0.42±0.02) PFHxA (0.57±0.21) PFHxS (0.70±0.17) 6:2FTOH(0.56±0.16), 1µM: PFBS (0.46±0.14) PFHxA (0.34±0.08) PFHxS (0.40±0.10) 6:2FTOH (0.47±0.09)). Further, migration was increased following exposure to 1nM 6:2FTOH at 12, 18, 24, 30, 36, 42 and 48 hour time points, with all $p \leq 0.001$ in HEK001 cells, while in HEK293, 1nM PFHxA, PFHxS, and 6:2FTOH decreased migration relative to DMSO controls. In Caco-2, TEER values were significantly higher following exposure to 1nM PFHxA, PFHxS, 6:2FTOH, and 1µM PFBS relative to controls, with 1nM PFHxS further demonstrating significantly increased cell invasion in Caco-2 cells. Overall, results indicate cell line specific differences in changes to cellular interactions following PFAS exposure, and highlight the need to better understand the cellular mechanisms and interactions underlying human exposure to short-chain PFAS and their ability to alter the functionality of cell and tissue systems following long term exposure.

5.02.P-We270 PFAS Risk Apportionment in California Public Wells - Source Differentiation and the Role of Wastewater Reuse

Anthony DeSalvo[1], Clare Pace[1], Rachel Morello-Frosch[1] and David Sedlak[1] (1)University of California, Berkeley

PFAS have been detected in a majority of California (CA) public supply wells, threatening the health of over 30 million Californians who rely on groundwater as their drinking water source. Contamination of groundwater has been associated with proximity to PFAS dischargers, though the relative contributions of different sources are not yet understood. We used public datasets on PFAS in CA groundwater and the locations of potential PFAS sources to differentiate the risk posed by 15 unique PFAS source types, including 6 types of wastewater reuse. We used generalized additive models to estimate the odds of California wells exceeding a concentration threshold of 4 ng/L for the 10 most frequently detected PFAS in California groundwater based on proximity to PFAS threats. In models adjusted for demographic, spatial, and environmental factors, wastewater reused for landscape irrigation was the strongest predictor of 8 out of 10 PFAS exceeding benchmark levels including PFOA, PFOS, PFBS, PFHxA, PFPeA, PFBA, PFHpA, and PFNA. Odds ratios ranged from 1.88 (CI: 0.9 – 3.9) for PFBS to 7.80 (CI: 3.5 – 14.3) for PFHpA. Other significant predictors were proximity to wastewater used for groundwater recharge, superfund sites, airports, paper mills, refineries, and biosolids application sites, though the odds ratios varied significantly across PFAS species. Differences in risk profiles were also noted between population density classifications, where PFAS exceedances were more likely in highly urbanized areas. Results indicate that not all PFAS sources can be considered equally in terms of risk posed to drinking water supplies. This work supports state efforts around targeted monitoring and remediation and informs the siting new drinking water sources.

5.02.P-We271 Total Organofluorine Testing Options for Closing the PFAS Mass Balance for Ecological Risk Assessments

Heather Lord[1] and Tammy Chartrand[2] (1)ALS Laboratories, (2)ALS Global

For ecological risk assessments involving PFAS, seeking closure on PFAS mass balance is desirable. PFAS in any environmental situation are nearly always present as a complex mixture so a cumulative effects approach is generally the goal. While a few hundred PFAS compounds are known to have been put into commercial production, environmental transformations of the less stable precursor compounds magnify the number of potential PFAS on a site. Targeted PFAS analyses are able to report about 60 compounds, of which relative potency factors have been published for about a third of these. In order for risk assessors to gauge uncertainty in a risk analysis, an understanding of the magnitude of the bulk of the unknown (dark) PFAS at a site is valuable. Two laboratory approaches are currently being used to assess the magnitude of dark PFAS in a sample: the Total Oxidizable Precursors (TOP) test – introduced in 2012 - and the Total Organofluorine (TOF) test, which started gaining traction in the late 2010s. It has become more prominent recently with the introduction the German DIN 38409-59 method in 2022 and US EPA Method 1621 in 2024. While both TOP and TOF are method defined parameters (MDP: a parameter defined solely by the method used to determine the analyte) TOF has some important strengths in assessments of dark PFAS. Notably, while TOP only assesses PFAS that can transform to reported stable end products – primarily PFAS carboxylates – TOF will report any captured PFAS. It also does a better job of capturing ultrashort PFAS and is faster and less expensive for the laboratory to report.

Four different preparation approaches are in use globally for TOF analyses: Adsorbable Organofluorine (AOF) for both soils and waters, and Extractable Organofluorine, again for both soils and waters. EOF and AOF have individual strengths and limitations. It is important to consider which is/are most appropriate for a given site. ALS offers all of these options from our Waterloo Ontario laboratory, along with a fifth 'Total Fluorine' option. In this presentation we will describe each of these approaches for generating a Total Organofluorine result.

5.02.P-We272 Recommended Toxicity Reference Values for Perfluorooctane Sulfonate and Perfluorohexane Sulfonate in Mammals and Perfluorooctane Sulfonate in Birds

Jason Conder[1], Christopher McCarthy[2], Jean Zodrow[1], Jenny Zenobio[2], Allison Narizzano[3] and Andrew East[4] (1)Geosyntec Consultants, Inc., (2)Jacobs Engineering Group Inc, (3)FMC Corporation, (4)EA Engineering, Science, and Technology, Inc., PBC

Perfluorooctane sulfonate (PFOS) and perfluorohexane sulfonate (PFHxS) are frequently detected in environmental media near per- and polyfluoroalkyl substance (PFAS) releases. Due to the persistence and relatively high bioaccumulation potential as well as the frequency and magnitude of detection at these locations, PFOS and PFHxS are key focuses of site-specific ecological risk assessments (ERAs) assessing potential exposures of avian and mammalian wildlife to PFAS. Toxicity reference values (TRVs) are a critical parameter in assessing effects to wildlife. For site-specific ERAs, TRVs are used to develop hazard quotients based on exposures calculated from food chain models and in deriving ecological screening values (ESVs) for abiotic media. Published mammalian and avian laboratory toxicity studies were reviewed with the goal of recommending TRVs for use in site-specific ERAs and ecological screening value derivation. Selection criteria prioritized oral exposure studies in birds and mammals evaluating effects on population-level apical endpoints, such as reproduction, growth, and survival. In all cases, reproductive effects were the most sensitive apical endpoint. The no-effect and low-effect avian TRVs for PFOS were 0.55 and 1.1 mg/kg-bw/d, respectively, as derived from a chronic dietary exposure study with Japanese quail. Mammalian TRVs were derived from chronic dietary exposure studies in deer mice. The no-effect and low-effect mammalian TRVs for PFOS were 0.25 and 0.5 mg/kg-bw/d. PFHxS was an order of magnitude less toxic than PFOS, with no-effect and low-effect mammalian TRVs of 7 and 14 mg/kg-bw/d. These TRVs are bracketed by doses within relatively straightforward dose–response relationships and are based on chronic exposure studies that evaluated a variety of apical endpoints clearly linked to population-level ecological health. Therefore, we propose these TRVs as they are considered robust and are appropriate for site-specific ERAs and ESV derivation.

5.02.P-We273 Evaluating the Influence of Environmental and Geochemical Processes on the Bioaccumulation of PFAS in Freshwater Fish

Kenia Whitehead[1] and Sara Hutton[1] (1)GSI Environmental

As regulatory actions—both state-driven and federally anticipated—continue to evolve, the number of sites where PFAS are the primary contaminant of potential concern (COPC) requiring site characterization and ecological and human health risk assessments is steadily increasing. Bioaccumulation potential plays a critical role in establishing protective risk-based criteria and selecting site-specific remediation strategies, including adaptive approaches. While published bioaccumulation factors are commonly used in risk assessments, their applicability across diverse environmental settings and aquatic species remains uncertain. This uncertainty is underscored by the substantial variability observed in field- and laboratory-derived bioaccumulation factors,

which can differ by several orders of magnitude—even for the same species and PFAS compound. Research has demonstrated that environmental and geochemical conditions influence the partitioning of PFAS among abiotic compartments, thereby affecting biological uptake potential. However, most studies on PFAS bioaccumulation do not account for site-specific physical and geochemical characteristics. This study integrates PFAS data for fish, sediment, and surface water with co-collected geochemical and environmental parameters using a simple regression-based framework. We demonstrate that a comprehensive understanding of PFAS bioaccumulation requires an interdisciplinary approach that incorporates environmental and geochemical factors into bioaccumulation estimates. Results from two field investigations—where spatially paired biota and abiotic media were collected alongside environmental and geochemical parameters—will be presented, supplemented by data from published studies. We further evaluate how these factors can be used to refine bioaccumulation estimates and reduce uncertainty in site-specific risk assessments. The presentation will conclude with recommendations for improving sampling designs to better characterize the site-specific environmental conditions that influence PFAS bioaccumulation.

5.02.P-We274 Scallions (Allium fistulosum) Exposure to Cerium Oxide Nanoparticles and Perfluorooctanesulfonic Acid

Cyren Rico[1], Riley Pope-Buss[2], Mary Fakunle[2] and Jacob Churchman[2] (1)Missouri State University, (2)Department of Chemistry and Biochemistry, Missouri State University, Springfield, Missouri 65897

The performance and responses of scallions to co-exposure to cerium oxide nanoparticles and perfluorooctanesulfonic acid (PFOS) were explored. Growth and biomass yield as well as metabolite and elemental profile, and PFOS uptake in scallions were measured. Results showed that scallions had higher tolerance to contaminant exposures exhibiting improved performance despite higher PFOS uptake and altered metabolite composition. This study could offer insights on how some plants could exhibit improved toxicity tolerance to contaminants.

5.02.P-We275 Per- and Polyfluoroalkyl Substances in Florida Invasive Freshwater Fish

Isabella Cioffi[1], John Bowden[1] and Michael Sipos[1] (1)University of Florida

Per- and polyfluoroalkyl substances (PFAS) are chemicals of emerging concern that are ubiquitous in nature and are linked to a litany of adverse health effects. These chemicals cause concern in aquatic environments as they infiltrate the food web at every trophic level. While studies of PFAS in marine mammals have been conducted, there is an information gap of PFAS in fish, with no studies completed on invasive Florida freshwater fish. To bridge this gap, muscle tissue samples (n=327) of freshwater invasive species (n=11) were collected at the 2024 and 2025 Southwest Florida (SWFL) Cooperative Invasive Species Management Area (CISMA) Invasive Fish Roundup held in Fort Myers, FL. The fish samples were collected in the surrounding counties from canals and retention ponds. Tissue samples were lyophilized and then extracted using an ion pair extraction method. The PFAS extracts were then analyzed for 41 PFAS via ultra high performance liquid chromatography tandem mass spectrometry (UHPLC-MS/MS), using a Thermo Vanquish and Quantis instrument, respectively. A total of 22 out of 41 PFAS were detected, with 16 PFAS that were quantifiable. The PFAS with the highest detection frequency were perfluorodecanoic acid (PFDA) and perfluoroundecanoic acid (PFUdA) at 95% while PFDA had the higher quantitation frequency at 89%. The PFAS with the highest concentration was linear perfluoroocatnesulfonic acid (L-PFOS) at 200 ng/g. This data will be used to help

better define fish health and potential human consumption risk. The presence of PFAS observed in both 2024 and 2025 supports that PFAS contamination is an urgent issue that warrants further investigation in the vulnerable SWFL freshwater fishery.

5.02.P-We276 Chronic Exposure of Americamysis bahia and Acartia tonsa to Seven per- and Polyfluoroalkyl Substances

Peter Key[1], Katy Chung[1], Marie DeLorenzo[1], Guilherme Lotufo[2] and David Moore[3] (1)National Oceanic and Atmospheric Administration (NOAA), (2)US Army Engineer Research and Development Center (ERDC), (3)U.S. Army Corps of Engineers

Per- and polyfluoroalkyl substances (PFAS) are a group of fabricated chemicals that includes such compounds as perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), perfluorohexanoic acid (PFHxA), perfluorohexane sulfonate (PFHxS), perfluorobutanoic acid (PFBA), and two fluorotelomer sulfonic acids (8:2 FTS; 6:2 FTS). These substances are used in non-stick and stain-resistant coatings, fire-fighting foams, and as a surfactant in industrial processes. Others are breakdown products of fluorinated products used in stain-resistant fabrics, paper food packaging, and carpets. The objective of this research was to characterize the effects of these seven PFAS on two sensitive crustacean species, mysid (Americamysis bahia) and copepod (Acartia tonsa). Chronic seven-day tests were performed with each compound for both mysids and copepods. The parameters measured, in addition to mortality, were growth, development, and fecundity. Copepods were significantly more sensitive to these PFAS than mysids. Effects of fecundity were observed in mysids, while effects on development were observed in copepods. The research with these PFAS compounds will add much needed data to assess whether these contaminants pose a risk to estuarine organism health.

5.02.P-We277 Risk Assessment of Representative PFAS To Model Estuarine Species

Katy Chung[1], Peter Key[1], Marie DeLorenzo[1], Guilherme Lotufo[2] and David Moore[3] (1)National Oceanic and Atmospheric Administration (NOAA), (2)US Army Engineer Research and Development Center (ERDC), (3)U.S. Army Corps of Engineers

Per- and polyfluoroalkyl substances (PFAS) are a group of persistent and widespread synthetic chemicals that pose environmental and public health issues worldwide. Currently little is understood with regard to the potential ecological risk posed by these substances particularly in marine environments. The objective of this study was to establish the acute toxicity threshold of seven PFAS compounds to five model estuarine organisms. Test species used were the mud snail (Tritia obsoleta), grass shrimp (Palaemon pugio), mysid (Americamysis bahia), sheepshead minnow (Cyprinodon variegatus), and copepod (Acartia tonsa). All species were tested in 48 or 96h aqueous exposures following established ASTM or USEPA protocols. PFAS compounds tested were perfluorooctanesulfonic acid (PFOS), perfluorooctanoic acid (PFOA), perfluorohexanesulfonic acid (PFHxS), perfluorohexanoic acid (PFHxA), perfluorobutanoic acid (PFBA), 6:2 fluorotelomer sulfonate (FTS), and 8:2 FTS. Measured LC50s from the acute tests for mud snails ranged from 11.89 (PFOS) to 238.47 mg/L (6:2 FTS); for grass shrimp 5.65 (PFOS) to 353.63 mg/L (PFHxA); for sheepshead minnows 2.49 (PFOS) to 595.1 (PFHxA); for mysids 1.47 (PFOS) to 131.63 (6:2 FTS) and for copepods 0.045 (PFHxA) to 20.443 mg/L (PFBA). Results from this study will address critical data gaps for PFAS in marine systems and thereby enable better informed and more cost-effective risk management decisions.

5.02.P-We278 The Effect of PFBA (Perfluorobutanoic Acid), PFPeA (Perfluoropentanoic Acid), and Bistriflimide on Plants: Insights From Lettuce (Lactuca sativa) Grown Hydroponically and in Soil

Leon Crepin Yameni Kakoua[1], Justine Fontaine[1], Sebastien Sauve[2] and Frederic Pitre[1] (1)University of Montreal, (2)University of Montreal (UdeM)

PFAS or “forever chemicals,” are contaminants of emerging concern generally defined by their resistance to degradation due to the C-F bond in their overall chemical structure. This allows them to accumulate in the environment, leading to environmental contamination. In an agricultural context, plants are exposed to PFAS present in water or soil. According to the scientific literature, this exposure may indeed affect not only the physiological parameters of plants but also their ability to absorb and bioaccumulate these contaminants in their various organs. The objective of our study was to examine the effects of PFBA, PFPeA, and bistriflimide on lettuce grown hydroponically and in soil, in order to compare their effects on the growth and development of this plant. Two experiments were conducted: Soil cultivation was carried out in 15 cm pots using a concentration of 17.5 µg/500 g of soil for each PFAS. Hydroponic cultivation was carried out using the deep water culture system, with the lettuce plants grown in 3.3 liter glass jars. Two concentrations were tested: 10 ng/L and 100 ng/L for each PFAS. The results of the soil experiment showed that PFAS concentrations found in the rhizosphere soil, leaves, and roots of lettuce varied depending on the treatment. In general, concentrations averaged between 2.2 ng/g and 3,4 ng/g in the leaves, 1.8 ng/g and 2,3 ng/g in the roots, and 0.2 ng/g and 720 ng/g in the rhizosphere soil. No significant differences in PFAS contents in the tissues were observed between the treatments, whether the contaminants were applied individually or in all three combinations. The same trend was observed for the leaf and root bioaccumulation factors. These factors averaged between 1 and 52 and between 2 and 101, respectively. The translocation factors ranged from 0.6 to 1.05 on average. Since these factors are close to 1, they indicate that lettuce is capable of rapidly translocating the different contaminants from the roots to the leaves. Overall, we concluded that soil-grown lettuce can absorb and bioaccumulate the three PFAS studied in its leaves and roots without, however, altering its physiological parameters. Our findings suggest that caution should be taken regarding PFAS accumulation in crops.

Keywords: PFAS, soil, environmental contamination, bioaccumulation.

5.02.P-We279 Implications of Short-Chain per- and Polyfluoroalkyl Substance (PFAS) Exposure on Earthworm (Eisenia fetida) Reproduction and Avoidance Behaviour

Olivia Coffield[1] and Ryan Prosser[1] (1)University of Guelph

Per- and polyfluoroalkyl substances (PFAS) are a large group of synthetic, fluorinated compounds utilized in an array of commercial and industrial applications. Decades of continued use without proper regulations combined with their relative slow degradation has led to the ubiquitous distribution of PFAS in the environment. In agricultural fields, the application of biosolids, a nutrient rich sludge produced as a byproduct of the wastewater treatment process, has been shown to be one of the potential pathways for PFAS to enter the environment. Despite the agronomic and economic benefits of biosolids, there is concern surrounding the practice of land application because of the potential introduction of contaminants, such as PFAS, to agricultural fields. However, the majority of PFAS that end up in agroecosystems lack toxicity data, making it difficult to properly characterize their ecological risk. To fill this knowledge gap, standardized avoidance and reproduction tests

were carried out to determine the potential adverse effects of PFAS on earthworms (Eisenia fetida), a keystone species in terrestrial ecosystems. A series of short-chain, understudied PFAS that have been frequently detected in soil, such as PFHxA, PFBA, and GenX, were tested by spiking artificial soil to concentrations ranging from 1 to 1,000,000 ng/g soil dry weight. In a 2-day test, earthworms were placed in avoidance chambers filled with alternating compartments of clean and spiked soil, during which their initial and final locations were recorded to determine movement in response to each of the PFAS. In comparison, a 2-month test allowed mature earthworms to reproduce for 4 weeks in soil spiked with one of the studied PFAS. Adults were then removed to allow any cocoons produced to develop for 4 weeks, after which the number of cocoons and juveniles were counted. Preliminary results suggest that earthworms are capable of sensing PFAS and avoid these compounds when present at relatively high concentrations in the soil. Additionally, exposure to the highest concentrations of each PFAS significantly reduced the number of offspring produced, but not in lower concentrations that would be considered environmentally relevant.

5.02.P-We280 Effects and Accumulation of PFAS Substances in Fluoropolymers in Adult Freshwater Mussels

Amila De Silva[1], Patricia Gillis[2], Erika Burton[1], Cassandra Brinovcar[1], Lisa Hoard[3], Harmony Ho[4] and C.James Bennett[2] (1)Environment and Climate Change Canada (ECCC), (2)Environment and Climate Change Canada, (3)Environment and Climate Change, (4)Environment and Climate Change canada

Fluorinated ionomers are a subgroup of fluoropolymers that are copolymers of tetrafluoroethene and perfluorinated vinyl ether monomer that possess an ionic moiety such as a sulfonic or carboxylic acid. The Government of Canada is conducting research to evaluate the ecological risk of fluoropolymers to aquatic life. Freshwater mussels (Unionidae) are an important sentinel species and are exposed to contaminants through multiple routes of exposure. We conducted a 14-day exposure using adult unionid mussels (Eurynia dilatata), individually housed in 1 L aerated beakers, at 20°C. A fine powder of insoluble fluoropolymer ionomer was tested at 7 treatment levels, with exposure solutions renewed every 3-4 days. Mussels and exposure media were analyzed for fluoropolymer-associated chemicals. All exposed mussels survived. Sub-lethal effects evaluated included oxidative stress and mussel behavior (i.e., filtering and burial). Nontargeted analysis by LC-Orbitrap mass spectrometry indicated the presence of hundreds of discrete PFAS chemicals occurring in homologous series in exposure media with repeating units of CF2, CF2CF2, and CF2O.

Disclaimer/Disclosure: This research was funded by the Chemicals Management Plan

5.02.P-We281 Compilation of Bioconcentration Factors Reported From PFAS-Exposed Laboratory Freshwater Fish Studies To Identify the Best Available Values and Integrate With Biomimetic Chromatography

Jason Magnuson[1], Boris Droz[2], Gerrad Jones[2], Jennifer Field[2] and Jason Conder[1] (1)Geosyntec Consultants, Inc., (2)Oregon State University

Per- and polyfluoroalkyl substances (PFAS) are frequently detected in the environment due to release from industrial applications and consumer products, such as textiles, non-stick cookware, food packaging, and firefighting foams. Due to their chemical stability, PFAS have a high environmental persistence and long-range transport, which can influence their bioaccumulation potential, largely related to their degree of fluorination.

Toxicokinetic models are used to predict the uptake of PFAS in aquatic organisms, although there remains an inconsistency between studies when establishing and using accumulation values, such as bioconcentration factors (BCFs). BCFs quantify the amount of chemical taken up into an organism relative to a waterborne exposure concentration. However, several factors tend to vary between studies that can create inconsistencies in reported BCF values, including tissue type, chemically validated exposure concentrations, multiple measures of PFAS across exposure duration, and steady state. In this study, BCF values (BCFs based on concentrations in whole body, fillet/muscle, and/or carcass) from published laboratory bioaccumulation experiments with freshwater fish exposed to water spiked with PFAS were reviewed and scored using a ranking system to identify the most reliable BCF values, with BCFs receiving a low, medium, or high-quality score. A total of 56 different PFAS were identified among 14 studies, with 36 and 20 reported BCF values scored as having either a high or low reliability, respectively. BCFs ranged across 10 orders of magnitude, from 0.28 to 1,100,000,000 L/kg, ww. There was a significant positive relationship between whole body log BCFs relative to perfluorinated chain length ($r2 = 0.72$, $P < 0.0001$) and molecular weight ($r2 = 0.71$, $P < 0.0001$). Additional relationships between biomimetic chromatography values and BCFs will also be discussed. This work identifies the best available BCF values from controlled, PFAS-exposed freshwater fish studies, providing a list of BCFs that can be used in food web models and risk assessment. In addition, relationships that can be developed between BCFs and biomimetic chromatography values would help us generate BCFs for PFAS that have not been tested with fish.

5.02.P-We282 Perfluorooctanesulfonamide (PFOSA) Exposure Alters Lipid Homeostasis in Larval Zebrafish (Danio rerio)

Erico Oliveira Pereira[1], Roomana Shams[2], Amany Sultan[2], Emma Ivantsova[2], Denina Simmons[1] and Christopher Martyniuk[2] (1)Ontario Tech University, (2)University of Florida

Perfluorooctanesulfonamide (PFOSA) is a synthetic organofluorine compound with an eight-carbon chain and a terminal sulfonamide functional group. It has been widely used in applications requiring grease- and water-repellent properties, such as food packaging. PFOSA has been detected in surface water, groundwater, and aquatic organisms, raising concerns about its environmental persistence and biological impacts. Several per- and polyfluoroalkyl substances (PFAS) have been reported to impact lipid metabolism in aquatic and terrestrial organisms, including fish species. The objectives of this study were to determine the effects of PFOSA exposure on lipid composition in developing zebrafish. We exposed 6-hour post-fertilization zebrafish eggs for 7 days to either embryo rearing media (ERM, media control), 0.1% dimethyl sulfoxide (DMSO, solvent control), 1 µg/L PFOSA, or 100 µg/LPFOSA (N=6; Petri dishes per experimental group containing 20 to 40 embryos). Zebrafish larvae (7 dpf) treated with 1 µg/L or 100 µg/L PFOSA did not show any difference in mortality to control groups, nor changes in lipid content based on oil red O staining. To better resolve effects on lipids, samples were analyzed using untargeted mass spectrometry (MS)-based analysis. We quantified 143 lipids with 14 lipid classes in total. Amongst the quantified lipid classes, 12 classes had lipids with statistically significant changes relative to the DMSO control across the two exposure groups (1 and 100 µg/L PFOSA). Overall, most lipids affected by PFOSA belonged to the phosphoinositide, ceramide, and phosphatidylethanolamine classes, suggesting disruptions in membrane signalling, cellular stress responses, and lipid metabolism. Lastly, we conducted targeted gene expression analysis on 12 transcripts related to lipid metabolism (e.g., acetyl-CoA carboxylase alpha (acaca), acetyl-CoA carboxylase (acc), acyl-CoA synthetase (acs), monoacylglycerol O-acyltransferase 2 (mogat2), peroxisome proliferator-activated receptor gamma (pparg), sterol O-acyltransferase

1 (soat1) and others). While elovl2 was increased in expression with increasing concentration, mogat2 expression was suppressed with PFOSA, as well as acaca and soat. These findings reveal potential lipid disruptions following PFOSA exposure and contribute to risk assessments for this chemical in aquatic environments.

5.02.P-We283 Assessing Data Availability for Aquatic Risk Evaluation of Seven Short-Chain PFAS

Tory Lydy[1], DYLAN RICKE[1], John Gondek[1] and Christopher McCarthy[1] (1)Jacobs Engineering Group Inc

Short-chain per- and polyfluoroalkyl substances (PFAS) are of growing interest for environmental risk assessment and water-quality standard development due to their persistence, mobility, and occurrence in aquatic systems. However, the availability of data needed to evaluate their aquatic toxicity and bioaccumulation potential varies substantially among compounds. This review compiled available aquatic toxicity and bioaccumulation information for seven short-chain PFAS: 6:2 fluorotelomer sulfonamide alkylbetaine (6:2 FTAB), 6:2 fluorotelomer sulfonic acid (6:2 FTS), perfluorobutanoic acid (PFBA), perfluorobutane sulfonic acid (PFBS), perfluorohexanoic acid (PFHxA), perfluoropentanoic acid (PFPeA), and trifluoroacetic acid (TFA). Aquatic toxicity data were compiled for freshwater and marine organisms, including algae, aquatic plants, invertebrates, fish, and amphibians, with emphasis on acute and chronic apical endpoints relevant to environmental threshold development. Bioaccumulation data were collated from peer-reviewed and grey literature sources, including bioaccumulation factors and bioconcentration factors for fish, shellfish, and other aquatic taxa. Studies were screened for reliability and relevance using established data-quality approaches. The review identified substantial differences in data availability among the seven PFAS. PFBA and PFBS generally had the most extensive toxicity datasets, while PFPeA, PFHxA, 6:2 FTS, and TFA had more limited datasets. 6:2 FTAB was represented by only a small number of freshwater fish early-life-stage toxicity studies. For bioaccumulation, PFBA , PFBS, PFHxA, and PFPeA had the broadest datasets, including fish and shellfish data. In comparison, 6:2 FTS had limited data, TFA was represented by only one aquatic plant study, and no bioaccumulation factors, bioconcentration factors, or suitable concentration data were identified for 6:2 FTAB. Overall, this review highlights data availability as a central limitation for evaluating short-chain PFAS in aquatic systems and identifies priority data gaps for TFA, 6:2 FTAB, chronic endpoints, marine organisms, and fish and shellfish bioaccumulation.

5.02.P-We284 Tissue Effect Concentrations and Evidence of Narcotic Modes of Action for PFAS in Pelagic Marine Aquatic Life

Jason Conder[1], Zacharias Pandelides[1], Nicholas Hayman[2] and Molly Colvin[2] (1)Geosyntec Consultants, (2)Naval Information Warfare Center Pacific (NIWC Pacific)

Per and polyfluoroalkyl substances (PFAS) can be detected in marine aquatic ecosystems near locations at which Aqueous Film-forming Firefighting Foams (AFFF) were used; however, the current understanding of the ecotoxicity of PFAS to marine aquatic life is limited. In this project, the lethal toxicity and bioaccumulation of 6 PFAS, as spiked into seawater at mg/L ranges, were evaluated using standard USEPA 7-day toxicity tests with mysid shrimp (Americamysis bahia) and topsmelt fish (Atherinops affinis). Median lethal concentrations (LC50s) were generated using concentrations in tissue, as estimated using LC50s calculated with PFAS water measurements and bioconcentration factors. Tissue LC50s for topsmelt tissue for PFDA, PFHxS, and PFOS

(the only PFAS that resulted in more than 50% lethality in topsmelt) were 0.25 to 1.0 mmol/kg, ww. Tissue LC50s for PFHxA, PFOA, PFDA, PFBS, PFHxS, and PFOS in mysids ranged from 0.58 to 3.9 mmol/kg, ww. The ranges of tissue LC50s in both species overlapped with lower end of the range of concentrations typically observed for organic chemicals that act via acute narcosis (i.e., 0.2 to 18 mmol/kg, ww). No clear differences for tissue LC50s were observed between PFCAs and PFSAs, and no clear relationship between tissue LC50s and perfluoroalkyl chain length was observed; this suggests that the potency of these PFAS are similar and that differences in toxicity values based on concentrations in water are due to differences in bioaccumulation. LC50s for topsmelt were approximately 2 to 8 times lower than those for mysids (for the three PFAS for which both topsmelt and mysid values were available), suggesting that topsmelt may be more sensitive than mysids. Overall, this evidence suggests that lethal toxicity of these PFCAs or PFSAs occurs via narcosis such that average (SD) tissue LC50s of 1.7 (1.2) and 0.60 (0.34) mmol/kg, ww would apply to marine invertebrates and fish, respectively. Tissue concentration effect values for sublethal endpoints were lower than those associated with lethality; for example, tissue no-effect (NOEC) values for growth in topsmelt and mysids were approximately 2.4 and 9 times lower (on average) than LC50s, respectively. These data will be helpful in developing criteria useful for quantifying risks using concentrations of PFAS in marine aquatic life at PFAS sites.

5.02.P-We285 Bound by Burden: PFAS Exposure In Utero

Russell Brummer[1], Darrin Thompson[2], Donna Santillan[2], Mark Santillan[2] and Joseph Charbonnet[1] (1)Iowa State University, (2)University of Iowa

Per- and polyfluoroalkyl substances (PFAS) are persistent environmental contaminants associated with adverse pregnancy and developmental outcomes. Although maternal and umbilical cord blood are commonly used to assess prenatal PFAS exposure, incorporating placental tissue into exposure assessments enhances understanding of the toxicokinetic processes governing fetal exposure. This study characterized PFAS distribution across the maternal–placental–fetal interface under typical exposure conditions. Concentrations of six PFAS (i.e., PFBS, GenX, PFHxS, PFOS, PFOA, and PFNA) were quantified in paired maternal plasma (n = 43), placental tissue (n = 35), and umbilical cord plasma (n = 43) collected from maternal–infant dyads in Iowa. Samples were analyzed by UHPLC-MS/MS. Maternal–placental partition coefficients (Kp), transplacental transfer efficiencies (TTEs), and inter-compartment correlations were evaluated. PFAS were detected across all biological compartments, with distinct compound-specific distribution patterns. Placental tissue exhibited the highest concentrations of PFOA, PFNA, and linear PFOS. Maternal plasma concentrations strongly predicted placental burdens (r = 0.77–0.95). Cord plasma concentrations were consistently lower than maternal concentrations. TTEs were compound dependent, with greater transfer observed for PFOA and PFNA than for PFOS. Isomer-specific analyses further revealed preferential placental accumulation of linear PFOS and enhanced fetal transfer of branched PFOS, suggesting that molecular structure influences placental transport and retention. These findings demonstrate that the placenta acts as an active regulator of fetal PFAS exposure rather than a passive conduit. Incorporating placental tissue alongside maternal and cord blood enables quantification of both Kp and TTE, providing complementary toxicokinetic metrics that improve estimation of fetal PFAS dose and reduce exposure misclassification in epidemiological studies. Ongoing analyses will evaluate associations between PFAS burdens and pregnancy complications, including gestational diabetes mellitus and preeclampsia, and investigate whether maternal PFAS profiles correspond with local drinking water contamination patterns. This integrated approach advances understanding of prenatal PFAS toxicokinetics and

strengthens environmental health risk assessment for susceptible populations.

Disclaimer/Disclosure: This research is supported by the Iowa Department of Natural Resources Grant/Program No: 18018200 and the Center for Health Effects of Environmental Contamination (CHEEC) Subaward No.: S04904-01.

5.02.P-We286 Sensitive Transcriptomic Points of Departure for PFOS and PFOS–Methylmercury Mixtures Support Improved Immunotoxicity Risk Assessment

Eric Levanduski[1], Philip Goodrum[2], Christopher Whipps[1] and Roxanne Razavi[1] (1)SUNY ESF, (2)GSI Environmental

Widespread environmental contamination of perfluorooctanesulfonic acid (PFOS) and methylmercury (MeHg) has triggered extensive monitoring programs to evaluate toxicological hazards [PG1.1]to human and wildlife health. For risk assessment, recent advances in the application of transcriptomic points of departure (tPoD) show promise as an alternative to traditional apical points of departure (aPoD) . Here, we exposed Zebrafish (Danio rerio) to nominal concentrations of MeHg (0.01-0.5 µg/L[PG2.1]) and measured concentration ranges of PFOS (29-141.5 µg/L), and their mixture (0.1 ppb MeHg and 56.0-192.1 µg/L), and assessed their resulting whole-body transcriptome using RNA sequencing. We observed significantly regulated genes among all groups, with the mixture-high [CW3.1]group having the most unique regulated genes (1418). Of the differentially expressed genes, immune markers were consistently among the highest in PFOS and mixture groups, including il1b, cxcl8a, and mmp9. This was mirrored in benchmark dose (BMD) analysis, where the gene ontology sets these genes are in (i.e., defense response, biotic stimulus, and external biotic stimulus) were the lowest pathways for the PFOS high group. The BMD values calculated here for PFOS (14.3 µg/L) and PFOS and MeHg mixture (11.8 µg/L) are more sensitive than aPoD and other tPoD studies, supporting the sensitivity of transcriptomic approaches. Benchmark doses for the mixture group supported antagonism between PFOS and MeHg, like previous mammal studies. From here, we built a potential adverse outcome pathway from upregulated gene targets and prior research, suggesting contaminant exposure to the immune compartment to be an important modulator for chronic inflammation and adverse aquatic health outcomes. These results build on current risk assessment goals of quantifying points of departure that link transcriptomics data to critical effect endpoints[P.

5.02.P-We287 Can Hazard-Based Models Reveal Hidden Developmental Effects of Environmentally Relevant PFAS Exposure in Mosquitoes?

Jadlyn Taylor[1], Isabella Beasley[1], Joseph Pitula[1] and Wayne Omagamre[1] (1)University of Maryland Eastern Shore

Per- and polyfluoroalkyl substances (PFAS) are persistent environmental contaminants that resist thermal, microbial, and chemical degradation. While high PFAS concentrations are known to impair insect development and survival, little is known about the biological consequences of environmentally relevant exposures. Because hormetic responses are often expressed at low contaminant concentrations, mosquitoes provide an ecologically relevant model for evaluating subtle developmental and behavioral effects of PFAS. This study investigated developmental, behavioral, and molecular responses of Culex pipiens exposed to environmentally relevant PFAS concentrations through three experimental approaches: exposure to a 17-congener PFAS mixture, PFBA-

only exposures, and PFOA-only exposures. Developmental endpoints included larval molting, pupation, adult emergence, response to probing, and vertical displacement in the water column. Adult feeding behavior was assessed using blood meals amended with PFAS. Developmental trajectories were evaluated using generalized linear models, hazard-based analyses, and Cox proportional hazards models, while transcriptomic analyses were used to identify molecular pathways associated with PFAS exposure. PFAS exposure significantly altered the temporal distribution of development, producing an accelerated hazard of adult emergence and a hormetic-like redistribution of developmental timing. Feeding activity was also elevated under PFAS exposure, suggesting behavioral stimulation at environmentally relevant concentrations. Analyses of PFBA and PFOA revealed evidence of a non-linear developmental response for PFBA, consistent with hormesis, whereas similar patterns were not observed for PFOA. Transcriptomic analyses further demonstrated widespread modulation of genes involved in redox regulation, energy metabolism, and immune function following PFBA exposure. Collectively, these findings suggest that PFAS may influence mosquito population dynamics through subtle developmental and behavioral shifts rather than overt toxicity. Hazard-based approaches may therefore provide a valuable framework for detecting ecologically relevant sublethal effects that are overlooked by traditional toxicological endpoints.

Disclaimer/Disclosure: This work was supported in part by the USDA NIFA, in partnership with the Maryland Legislation. Any opinions, findings, conclusions, or recommendations expressed in this work are those of the author(s) and should not be construed to represent any official USDA or US Government policy

5.02.P-We288 Effects of PFOS on Thyroid Hormone–Driven Development of Tadpole Olfactory Epithelium

Emma Field[1], Rikke Poulsen[2], Helena Petrosova[1] and Caren Helbing[1] (1)University of Victoria, (2)Aarhus University

The anuran olfactory system is highly distinct between aquatic tadpole and terrestrial frog life stages and must remodel extensively during thyroid hormone (TH)-dependent metamorphosis. The olfactory epithelium is the most TH-sensitive tadpole tissue studied to date and plays a critical role in regulating behavior, making it a sensitive bioindicator for TH disruption using both molecular and behavioral endpoints. Mass spectrometry imaging (MSI) is a powerful technique that combines mass spectrometry with spatial information, enabling visualization of biomolecule distribution in tissue sections. In ecotoxicology, this approach can be used to understand how pollutants are distributed in organisms and their effect on endogenous biomolecules. Herein, we utilized MSI to investigate the distribution and effects of persistent pollutant perfluorooctane sulfonate (PFOS) on premetamorphic Rana catesbeiana tadpoles at doses ranging from 0-100 µg/L for 48 hours. Tadpole heads, including olfactory epithelium and brain, were sampled for analysis. PFOS was selectively localized to the olfactory epithelium and disrupted lipids in this tissue, raising questions about its impacts on TH-dependent development and behavioral regulation. Notably, diacylglycerol, which is an important olfactory signaling molecule, was perturbed by PFOS exposure in the olfactory epithelium. Exposure of this vital sensory tissue to legacy contaminant PFOS provides the unique opportunity to link molecular effects with behavioral outcomes, helping to construct a new adverse outcome pathway for TH disruption.

5.02.P-We289 Evolution of PFAS Bioaccumulation Science and Implications for

Managing Risk Under Increasing Regulatory Scrutiny

John Toll[1] and Kelly Croteau[2] (1)Barr Engineering, (2)Barr Engineering Co.

Understanding of PFAS bioaccumulation has evolved in recent years. Substantive content of the evolving science, pace of change, and expansion of regulatory scrutiny all have implications for how stakeholders evaluate and manage environmental risk. Evolution of the science is reshaping both the technical basis for risk assessment and the expectations placed on regulated parties, underscoring the critical role of specialized expertise in navigating this rapidly changing landscape. Early work attempted to interpret PFAS bioaccumulation using models developed for hydrophobic organic contaminants (HOCs), emphasizing lipid partitioning. More recently, the knowledge that PFAS bioaccumulation is governed by protein binding, phospholipid interactions, and active transport processes is influencing public discourse and has necessitated a departure from the HOC framework, but these challenges are being met and tools are emerging for understanding and managing the risks posed by PFAS in human and wildlife food supplies. As of 2026 perfluorooctane sulfonic acid (PFOS) is the PFAS with the most widely established fish/shellfish tissue thresholds for health protection, found in federal guidance, at least 15 U.S. states, and Ontario/Great Lakes agencies. A few jurisdictions have also set numeric triggers for perfluorooctanoic acid (PFOA) and perfluorononanoic acid (PFNA), reflecting local contamination concerns. Other PFAS are managed under the umbrella of PFOS-focused advisories and continued surveillance. Moving forward, more regions are likely to harmonize with the most protective standards (tens of ng/g or lower for PFOS in fish) and incorporate additional PFAS as toxicity data emerge. Scientific developments are occurring alongside evolving regulatory expectations, increasing investigation requirements, and heightened stakeholder scrutiny. Regulated parties are facing growing pressure to demonstrate that PFAS risks are understood and being actively managed using technically defensible approaches. This need is driving demand for environmental scientists and engineers who can interpret complex and often incomplete datasets, apply mechanistic bioaccumulation models, and design targeted investigations that reduce uncertainty and inform decision-making. This presentation provides an overview of the evolution of PFAS bioaccumulation science, and demands on environmental risk assessors and managers, and highlights why these advances matter for regulated parties.

Advances in the Ecotoxicology and Risk Assessment of Per- and Polyfluoroalkyl Substances

5.02.T.B-01 Beyond Apical Endpoints: Bioaccumulation and Transformation of Emerging PFAS in Fathead Minnow Early Life Stages

Erin Ussery[1], Molly Dobrik[2], Jessie Cunningham[3], Hufsa Khan[3], Christine Lavalle[3], Amy Sett[3], Cassandra Brinovcar[1] and Amila De Silva[1] (1)Environment and Climate Change Canada (ECCC), (2)McMaster University, (3)Environment and Climate Change Canada

Per- and polyfluoroalkyl substances (PFAS) are ubiquitous environmental contaminants, yet toxicological data for many emerging PFAS remain limited, creating challenges for ecological risk assessments of PFAS-impacted aquatic environments. Improving understanding of the toxicity, bioaccumulation, and environmental transformation of emerging PFAS is critical for informing regulatory decision-making and site-specific risk evaluations. This study evaluated the developmental, growth, behavioral, bioaccumulation, and transformation potential of two understudied PFAS, perfluorobutane sulfonamide (FBSA) and 5:3 fluorotelomer carboxylic

acid (5:3 FTCA), using a 21-day early life-stage toxicity test with fathead minnows (Pimephales promelas). Embryos were exposed to FBSA and 5:3 FTCA concentrations ranging from below environmental relevance, environmentally relevant through above environmental relevant concentrations through 16-days post hatch. Endpoints included survival, hatching success, growth, developmental abnormalities, and larval swimming behavior. Concentrations of parent compounds and transformation products were quantified in exposure media and larval tissues to assess bioaccumulation and environmental transformation processes.

No significant effects were observed for any apical endpoint following exposure to either compound. However, measurable concentrations of FBSA and 5:3 FTCA were detected in exposure media and exposed larvae, demonstrating uptake and bioavailability under test conditions. In addition, multiple transformation products of 5:3 FTCA were identified in exposure media, indicating active transformation during the exposure period. Together, these data provide important information on the environmental fate and biological exposure potential of FBSA and 5:3 FTCA that can be incorporated into ecological risk assessments and regulatory evaluations of PFAS-contaminated aquatic environments.

5.02.T.B-02 Bioaccumulation Evaluation of Aqueous Film-Forming Foam Relevant per- and Polyfluoroalkyl Substances in Marine Benthic Invertebrates

Nicholas Hayman[1], Zacharias Pandelides[2], Molly Colvin[1], Gunther Rosen[3], Josiah Discar[4], Jennifer Arblaster[2] and Jason Conder[2] (1)Naval Information Warfare Center Pacific (NIWC Pacific), (2)Geosyntec Consultants, Inc., (3)NIWC Pacific, (4)Naval Information Warfare Center Pacific

The limited availability of PFAS bioaccumulation data for benthic marine aquatic life hinders the assessment of ecological risks of PFAS in sediment, leading to uncertainty in determining remediation and compliance requirements at potential PFAS sites. This study evaluated the bioaccumulation of 6 AFFF-relevant PFAS compounds (PFOA, PFDA, PFHxS, PFOS, PFDS, and 8:2 FTS) over 28 days using two standard benthic species, the clam Macoma nasuta and the marine polychaete Nephtys caecoides. Clean sediment from Carr Inlet (WA, USA) was spiked with target PFAS. Organisms were exposed to PFAS individually at mg/kg levels (1-40 mg/kg sediment dry weight) and in two mixtures at lower levels (one 10X lower and the other 100x lower in concentration than the single PFAS exposures). An additional 9 PFAS were detected in sediments and tissues (likely trace impurities associated with the targeted PFAS), expanding the data set to a total of 15 PFAS. Tissue (polychaete) and sediment samples were collected weekly over a 28-day period to assess bioaccumulation over time, while clam tissue was collected at 28 days. Initial sediment concentrations were within ± 20% of nominal concentrations. Due to overlying water exchanges (per test protocols), some PFAS were lost in significant amounts during the 28-day test. For example, PFOA and PFHxS, more mobile PFAS; concentrations in sediment decreased over time such that only ~30% of the initial concentration in sediment remained at 28 days. In contrast, concentrations of longer chained PFAS (PFAS with 8 or more perfluorinated carbons) remained within approximately 40% of initial concentrations over the course of the test. There were substantial differences in PFAS bioaccumulation between the two benthic species, with polychaete showing approximately an order of magnitude higher concentrations. Bioaccumulation factors (BAFs) were calculated using concentrations in biota and passive sampler derived sediment porewater measurements; BAFs increased with perfluorinated chain length for both species and were generally within a factor of 2 to 6 of BCFs observed in marine pelagic species exposed to spiked water. This suggests that PFAS are conforming to equilibrium partitioning theory such that the freely dissolved fraction in sediment controls the bioavailability of PFAS in

sediment. These data will provide improved ecological risk assessment of PFAS-impacted sediments, resulting in data-backed remediation and cleanup requirements.

Disclaimer/Disclosure: This project is funded by the Strategic Environmental Research and Development Program (Project ER22-3214) and by Navy Environmental Sustainability Development to Integration (Project 601).

5.02.T.B-03 Probabilistic Environmental and Human Health Risk Assessments for Short-Chain Perfluorinated Substances Associated With the Montreal Protocol

Mark Hanson[1], Mads Sulbæk Anderson[2], Timothy Wallington[3] and Keith Solomon[4] (1)University of Manitoba, (2)California State University, (3)University of Michigan, (4)University of Guelph

Short-chain perfluorinated acids are increasingly being detected in surface-water and other matrices. Use of probabilistic ecological risk assessment was pioneered in 1994 with the conclusion of the USEPA-SETAC ARAMDGP workshop. This method for characterizing risks makes use of probability distributions of environmental exposure-concentrations and sensitivity (LC50s, NOECs) of organisms to determine likelihood of adverse effects at the community level. The first use of this approach was in an ecotoxicological risk assessment of atrazine published in 1996 in ET&C. This presentation will illustrate the use of probabilistic methods to characterize risks associated with degradation products of refrigerant gases falling under the purview of the Montreal Protocol and its amendments. These degradants are trifluoracetic acid (TFA), perfluoropropanoic acid (PFPrA) and perfluorobutanoic acid (PBFA), all of which are soluble in water, which is also their ultimate sink. As salts, these substances are very stable, persistent, have no known natural mechanisms of degradation, or biological receptors. Data on NOECs for aquatic organisms were obtained from the literature, converted to Na-TFA and plotted as cumulative frequency distributions (CFDs) along with CFDs of concentrations in the surface- and groundwater and some food matrices. Assessment of risks to humans was semi-probabilistic. Here the lowest NOEL from laboratory animal testing (a 90-d rat study following the OECD TG408 guideline) which provided a value of 10 mg Na-TFA kg d^{-1}. For comparison to environmental concentrations, benchmarks were derived from NOELs by using the WHO guideline of consumption of water of 2 L d^{-1} for a 70 kg person and 1 L d^{-1} for a 10 kg child. As is normal procedure for substances that are not-genotoxic, carcinogenic, or non-teratogenic, the benchmarks were derived by dividing the NOEL by an uncertainty factor (UF) of 10 for animal to human and 10 for normal human to sensitive human (10 × 10) = UF of 100). This gave deterministic benchmarks of 1 x 106 and 3 x 106 ng kg^{-1} d^{1}, which were graphically compared to distributions of concentrations in water or liquid food. In a total of > 24 published studies based on a total of 4338 exposure samples the CDFs for exposures, NOECs for aquatic organisms, benchmarks for humans did not intersect, indicating de minimis risks. However, in environmental samples from some industrial sites, the margins of exposure were close to being of concern.

5.02.T.B-04 A Case for Including Bats When Assessing Effects of Emerging Contaminants

George Huddleston[1] and Jenna Molaro[1] (1)Copperhead Environmental Consulting Inc.

Emerging contaminants pose an increasing threat to bat populations in North America, yet bats remain largely excluded from ecological risk assessment (ERA) frameworks. This study examines insectivorous bat exposure to per- and polyfluoroalkyl substances (PFAS) and microplastics. Approximately 70 percent of North American

bat species are obligate insectivores that consume up to half their body weight in prey each night. Aquatic emergent insects accumulate waterborne contaminants during larval development and retain them through metamorphosis, serving as trophic transfer vectors to bats. Additional exposure routes include dermal absorption during water skimming and maternal transfer during critical developmental windows. Protein binding drives PFAS bioaccumulation, with biomagnification factors of 2 to 10 times per trophic level in aquatic food webs. Recent field studies confirm PFAS presence in wild bat guano and microplastics in gastrointestinal tracts of North American bats. Adverse effects include hepatotoxicity, immunosuppression, reproductive impairment, and disrupted hibernation physiology—outcomes that could synergistically exacerbate existing threats such as white-nose syndrome. We propose an adapted ERA framework that incorporates bat-specific endpoints, non-invasive biomonitoring, and pharmacokinetic modeling. Critical knowledge gaps persist regarding chronic low-dose PFAS mixture effects, microplastics acting as vectors within insect prey, and the cumulative impacts of these stressors with existing threats. Integrating bats into standardized ERA frameworks is essential for conserving these ecologically and economically vital species.

5.02.T.B-05 Soil Mobility and Plant Uptake of PFAS

Sébastien Sauvé[1], Toyin Saliu[1] and Libby Morales[1] (1)Université de Montréal

PFAS can accumulate in soils, and the downward leaching potential can be estimated using solid-liquid coefficients (Kd). Using compiled Kd values for per- and polyfluoroalkyl substances (PFAS), we can estimate the soil quality threshold to prevent groundwater concentrations from reaching drinking water quality criteria for PFOA and PFOS. In this study, the distribution coefficients (log Kd) of 77 PFAS were investigated in 84 soils from the vicinity of Lyon, France. Additionally, we investigated the transfer of this PFAS to vegetations growing on these soils.

Among the 77 PFAS investigated, 14 were detected in the aqueous phase, mainly short-chain PFAS, which enabled the estimation of their Kd values. With soil concentrations ranging from 0.06 to 6.8 µg/kg for PFOA and 0.15 to 33 µg/kg for PFOS, the Kd values ranged from 1.01 to 3.2 mL/g (PFOA) and 1.7 to 3.5 mL/g (PFOS). For the short-chain PFCAs, Kd values ranged from 1.3 to 2.9 mL/g for PFBA (C4) and from 0.08 to 2.4 mL/g for PFPeA (C5). Overall, PFAS Kd values generally increased with increasing chain length, indicating stronger sorption of longer-chain PFAS to the solid phase.

For PFAS uptake in plants, bioaccumulation factors were highest for short-chain PFCAs, particularly PFPrA (13.8 ± 21.8), PFHxA (7.8 ± 22.8), PFBA (7.6 ± 7.3), and PFPeA (5.3 ± 10.8). However, some source-related long-chain PFAS, including PFNA (C9) and PFUnDA (C11), were also detected in plants. This suggests that strong industrial inputs can promote measurable accumulation of less-mobile PFAS, including those with relatively high Kd values, in vegetation.

Long-chain PFAS, like PFOS and, to a lesser extent, PFOA, have some retention on soil surfaces and are not easily taken up by plants, yet the concentrations accumulated in plant tissues might still be of concern given their inherent toxicity at low doses. Shorter-chain PFAS such as PFHxA, PFBA, PFPeA, PFPrA, and PFNA are, on the other hand, much more readily taken up by plants. The toxicity information available for shorter PFAS is less extensive than that for PFOA and PFOS, but the higher observed plant concentrations of short-chain PFAS highlight the need to acquire more information on their potential for bioaccumulation and toxicological effects. Results from plant uptake studies on PFAS accumulation are presented, highlighting research needs and PFAS that require greater focus.

5.02.T.B-06 An Evaluation of Approaches to Summing Concentrations of per- and Polyfluoroalkyl Substances in the Presence of Non-Detects Using Real and Simulated Datasets

Shaun Roark[1], Alexander Wilson-Fallon[1], Suzanne Ball[1] and Christopher McCarthy[1] (1)Jacobs

Measures of total per- and polyfluoroalkyl substances (PFAS) in tissue and environmental media are frequently reported in the literature, and some guidelines are based on total PFAS or sums of specific PFAS. However, approaches to summing are not always fully described, adding uncertainty to comparisons among studies or to guidelines. Total PFAS sums may depend on handling of non-detects, particularly when a substantial proportion of some PFAS results are below laboratory detection limits. We have elsewhere reported results for egg tissue concentrations of 41 PFAS measured in 185 common loon eggs, 32 osprey eggs, and 15 double-crested cormorant eggs from 31 sites across Maine, and 144 common loon eggs from New Hampshire. In those datasets, 12 PFAS were detected in more than 75% of samples and 20 were detected in fewer than 25% of samples, with four of the latter never detected. Total PFAS was estimated by summing the most frequently detected 13 PFAS (tPFAS13) using ½ the method detection limit (MDL) for non-detected results. To evaluate the implications of estimating tPFAS13 instead of summing 40 PFAS (tPFAS40), tPFAS13 was compared to tPFAS40 (also using ½ MDL for non-detects) to determine the percentage of tPFAS40 represented by tPFAS13 for each sample. Of 376 results, that percentage ranged from 71.6% to 100%. Thirty-six egg samples had a percentage between 71.6% and 90%, and 340 egg samples had a percentage greater than 90%. The percentage of non-detects in tPFAS13 was 12% (95% confidence interval [CI], 11.1 to 13%), and in tPFAS40, it was 60.1% (95% CI, 58.7% to 61.6%). While tPFAS13 underestimated the total relative to tPFAS40 in samples with the greatest concentrations, the larger portion of non-detects in tPFAS40 added uncertainty and did not necessarily provide a better estimate of the total in all samples, particularly those at the lower concentrations. In this presentation, we explore the effect of the detection frequency threshold for inclusion of PFAS in the estimate of total PFAS, the use of common substitutions for non-detects (0, ½ MDL, MDL), and censored data methods (such as Kaplan Meier) using the reported bird egg PFAS results and a series of simulations to characterize the uncertainty among approaches to estimating total PFAS. The results provide a basis for recommendations on detection frequency thresholds for inclusion of PFAS in sums and for handling non-detects in summing PFAS.

Advancing Human and Ecological Risk Assessment Using Microbial and Invertebrate Models

5.03.P-We212 A Combined Computational and Experimental Approach To Assess Mefenpyr-Diethyl Toxicity in Soil Organisms

Alek M. Owens[1], Cody Sturgeon[2], Pavitar Singh[1], Femi Oloye[1] and Oluwabunmi Femi-Oloye[1] (1)University of Pittsburgh at Bradford, (2)University of Pittsburg at Bradford

Herbicide safeners such as mefenpyr-diethyl are incorporated into herbicide formulations to protect crops from the phytotoxic effects of active ingredients. Understanding their environmental impact, particularly on soil organisms like earthworms is essential for maintaining healthy soils that support plant growth. Because earthworms play a critical role in soil structure and nutrient cycling, any chemical that harms them may

indirectly impair crop productivity. This study highlights the potential risks associated with prolonged accumulation of safeners in soil and their implications for wildlife and human health. To evaluate the toxicological profile of mefenpyr-diethyl, in silico prediction tools including SwissADME and the Toxicity Estimation Software Tool (TEST) were used. Subsequently, a filter paper test was conducted in which Eisenia fetida were exposed to 3 mL of mefenpyr-diethyl at concentrations of 5, 2.5, 1, 0.1, 0.01, and 0.001 ppm. A parallel artificial-soil test was performed using the same concentration range. All experiments were conducted at room temperature. In silico predictions estimated an oral LD_{50} of 2000 mg/kg, corresponding to a toxicity rating of 4 (moderate toxicity). In the filter paper test, mortality increased with concentration, and worms exposed to higher doses died sooner than those in lower-dose or control groups. In the artificial-soil test, assessed at 7 and 14 days, concentrations of 1 ppm and above caused mortality and observable morphological alterations. Overall, the results indicate that mefenpyr-diethyl exhibits measurable toxicity toward Eisenia fetida at concentrations of approximately 1 ppm and higher. These findings suggest that environmental exposure to safeners should be minimized to reduce potential harm to soil ecosystems.

5.03.P-We213 Exploring Nitrogen Fixation in Lichen-Associated Microbial Communities

Connor Cornelius[1] and Oluwabunmi Femi-Oloye[1] (1)University of Pittsburgh at Bradford

Lichen have well known abilities in withstanding extreme, fluctuating environments and playing a kye role in ecological succession as a pioneer species. They are symbiotic associations between a fungal partner (mycobiont) and a photosynthetic partner (photobiont), which is typically a green alga or cyanobacterium. In some lichens cyanobacteria partner with the fungus, contributing to nitrogen fixation in environments that are nutrient-poor. The extent of which associated bacterial communities contribute to nitrogen fixation in local lichen populations remains unclear. This study aims to isolate and examine traits of bacteria associated within lichen thalli collected from tree and rock substrates in Bradford, Pennsylvania. Bacterial isolates will be screened for the presence of the nifH gene, a key marker for nitrogen fixation, using polymerase chain reaction analysis. Positive samples will be further identified through 16S rDNA sequencing. This work will help to advance knowledge on whether cyanobacterial counterparts associated with lichen contribute to nitrogen fixation within Bradford, PA, particularly in conditions where there may be limited photosynthetic activity. It will also improve understanding of the survival strategies of lichen in temperate environments.

5.03.P-We214 Myco-Restoration: Optimizing Fungal Degradation of Plastics Using Pleurotus ostreatus

Jacob Troutman[1] and Oluwabunmi Femi-Oloye[1] (1)University of Pittsburgh at Bradford

As the human population increases there is a demand for plastic products that are produced by corporations. Large amounts of plastic are not properly recycled which causes the introduction into the environment. This cycle of plastic pollution continues to impact flora, fauna, and the overall health of the environment. The degradation of plastic is slow which allows it to remain in the environment for hundreds of years. A new biodegradation technique called mycorestoration uses mycelium networks for restoration such as plastic degradation. A common fungus known as Pleurotus ostreatus helps aid the degradation of the plastic polymers by releasing enzymes such as laccases and peroxidases. The release of these extracellular enzymes break down the complex plastic polymer chains into smaller units. In this experiment polyurethane and polyethylene plastics

will be exposed to the oyster mushrooms for an extended period of time. Degradation of the plastic will be analyzed by physical, chemical, and structural changes caused by the secreted enzymes. This will enhance the knowledge of oyster mushrooms to degrade plastic used frequently in the world. Overall, introducing plastic degradation by Pleurotus ostreatus provides a potential landfill bioremediation, edible source, and development of plastic alternatives.

Antimicrobials in the Environment: Chemistry, Fate and Ecotoxicity

5.04.T-01 Antimicrobial Cleaning Product Usage Among Chicago Households With Pregnant Individuals

Shelby J. Tillema[1], Mary Akel[2], Leena B. Mithal[3], Stephanie A. Fisher[4], Tonia N. Branche[3] and Erica M. Hartmann[1] (1)Department of Civil & Environmental Engineering, Northwestern University, Evanston, IL, (2)Ann and Robert H. Lurie Children's Hospital, Chicago, IL, (3)Ann and Robert H. Lurie Children's Hospital, Chicago, IL; Department of Pediatrics, Feinberg School of Medicine, Chicago, IL, (4)Department of Obstetrics and Gynecology, Feinberg School of Medicine, Chicago, IL

Antimicrobials in consumer cleaning products may pose human and environmental health risks. Knowledge regarding what kinds of cleaning products households use, and whether consumers understand the nature of their products, is limited. The Chicago Perinatal Origins of Disease & Founders' 400 Initiative is a cohort study following 400 birthing parent-infant dyads up to 2 years postnatally across the Chicago metropolitan area. Participants completed a survey in the second trimester reporting product names and pictures of cleaning products (e.g., surface cleaners, soaps, and wipes). Participants were also asked to identify which of their products included the words "antimicrobial", "antibacterial", or "disinfectant" on the label. The objective of this study is to understand 1) what cleaning products are being used by research participant households, and 2) label clarity and consumer understanding of antimicrobial products. Preliminary analysis of data from 24 participants during pregnancy demonstrates the broad range of commercially available cleaning products (33 brands, 65 unique products, 129 total products reported). Most participants (72.2%, 13/18) who sent confirming photos used at least one antimicrobial product in their homes (24 products). Among a broad range of active ingredients reported, quaternary ammonium compounds (QACs) were dominant (62.5%, n = 15/24 products). Nearly half of participants (44.5%, 8/18) who provided photos of confirmed antimicrobial products did not identify these products as stating "antimicrobial," "antibacterial," or "disinfectant" on their labels. This study documents the household use of antimicrobial cleaning products in the U.S., yielding insights into what types of products people use and what they understand about these products. These results suggest a potential lack of clarity in antimicrobial product labeling, versus consumer misunderstanding of the nature of antimicrobial products and their environmental persistence. This information is key towards understanding household and infant exposure to consumer antimicrobial cleaning products and ingredients like QACs, as well as understanding consumer confusion about the purpose and use of antimicrobial cleaning products.

Disclaimer/Disclosure: This study is funded by the Founders' Board of Lurie Children's Hospital and is based upon work supported by the National Science Foundation (NSF) Graduate Research Fellowship (Grant No. DGE-2234667). This material expresses the views of the authors and does not necessarily reflect the views of NSF.

5.04.T-03 Risk of Quaternary Ammonium Compounds in San Francisco Bay

Ezra Miller[1], Taylor Hoxie[2], Anna Mahoney[2], Miguel Méndez[1], William Arnold[2] and Rebecca Sutton[1] (1)San Francisco Estuary Institute, (2)University of Minnesota

Quaternary ammonium compounds (QACs) are a class of emerging contaminants used in a wide swath of consumer, industrial, and medical products as antimicrobials, surfactants, preservatives, antistatic and softening agents, and dispersants. They are often found in cleaning products, hand sanitizers, cosmetics, detergents, disinfectants, fabric softeners, lotions, mouth washes, nasal sprays, shampoos, many kinds of wipes, and various pesticidal products. Anticipating increased use of antimicrobials during the COVID-19 pandemic, the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP) began monitoring for QACs in pathways leading to the Bay (wastewater and stormwater runoff), as well as Bay water and sediment in 2020. These initial data indicated ecotoxicity threshold exceedances in Bay water with risk quotients (the ratio of observed concentrations to available ecotoxicity threshold values) between 1 and 50 for select QACs, and justified future surface water monitoring to place QACs in the RMP's tiered risk-based framework for emerging contaminants. The RMP uses a risk-based screening method to assign appropriate levels of concern regarding the potential to impact Bay wildlife and people. This framework guides prioritization of future monitoring and recommended management actions. More comprehensive monitoring of QACs in Bay water was undertaken in 2024 to provide a more robust basis for risk evaluation. Results indicate that QAC use may be decreasing, yet they may pose risks to sensitive Bay species, including threatened sturgeon.

Disclaimer/Disclosure: This work was funded by the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP).

5.04.T-04 Effects of Whole-Lake Additions of an Antimicrobial on the Host Microbiome of Aquatic Insects and Riparian Spiders

Sara Gharouni Saffar[1], Karen Kidd[1], Milena Esser[1], Lauren Timlick[2] and Jose Luis Rodriguez Gil[2] (1)McMaster University, (2)IISD-Experimental Lakes Area

Benzalkonium chloride (BAC) is an antimicrobial commonly used in disinfectants, sanitizers and personal care products, and its use in industrial, clinical, and household settings has increased globally. It has been detected in surface waters downstream of municipal wastewater treatment plants and, as such, there is concern over its effects on non-target organisms. A whole-lake experiment is being done at the IISD – Experimental Lakes Area in northwestern Ontario, Canada, to assess the effects of BAC on the food web. Baseline sampling was done in 2024, and BAC additions (target 2,000 ng/L) occurred weekly from June to October of 2025. As part of this larger study, we collected macroinvertebrate larvae and adults (dragonflies, damselflies, chironomids, mayflies) and their riparian spider predators (tetragnathids and araneids) before and during BAC additions from the experimental and reference lakes to assess effects on host microbiomes. Bacterial DNA was extracted from whole invertebrates (n=6-10/taxon), and the communities were characterized using 16S rRNA gene amplicon sequencing. Baseline data from 2024 indicates that larval insects had the highest diversity of ASVs whereas spiders had the lowest diversity across both lakes. Multivariate analyses indicated that the bacterial communities of larval insects differed among taxa and lakes and were mainly dominated by the phylum Pseudomonadota (except tetragnathids and chironomids). In contrast, tetragnathid spiders and chironomids were dominated by the phylum Bacillota. Endosymbionts such as Spiroplasma, Wolbachia, and Tyzzerella were

found in some insect larvae and all spiders. Analyses of 2025 samples suggest that alpha diversity remained relatively stable in most taxa after BAC exposure, while bacterial community composition showed taxon-specific shifts across sites and years. The relative proportion of endosymbionts decreased in some taxa, suggesting that these microbes may be more sensitive than overall diversity of metrics. Ongoing analyses of data from other invertebrate taxa will advance our understanding of how BAC exposure affects host microbiome composition and endosymbiont dynamics in this lake food web. Given the importance of microbiota in nutrient acquisition, immune function and reproduction, shifts in their composition may have adverse effects on aquatic insects and their predators riparian spiders.

5.04.T-05 Quaternary Ammonium Compounds in the Surface Water of San Francisco Bay

Taylor Hoxie[1], Rebecca Sutton[2], Miguel Mendez[2] and William Arnold[1] (1)University of Minnesota, (2)San Francisco Estuary Institute

Quaternary ammonium compounds (QACs) are commonly added to a variety of consumer products for their disinfecting, sanitizing, and antimicrobial properties, leading to their release to surface waters via wastewater effluents. QACs are also incorporated into building materials and are regularly used as biocides to prevent the growth of moss, mold, and algae on roofs. These applications may lead to additional inputs of QACs into surface waters during storm events. This contamination is concerning because QACs are toxic to aquatic life. Surface water samples were collected across various locations in the San Francisco Bay to evaluate QAC concentrations and to aid in assessing associated risks. Water samples were also collected following storm events in an effort to assess QAC runoff from the urban environment. All samples were analyzed for 17 different QACs via liquid chromatography tandem mass spectrometry (LC-MS/MS). An additional 5 QACs were evaluated via non-targeted analyses. The analyte list covers four main subcategories of QACs including the benzalkyldimethylammonium compounds (BACs), the ethylbenzalkyldimethylammonium compounds (EtBACs), the alkyltrimethylammonium compounds (ATMACs) and the dialkyldimethylammoinium compounds (DADMACs). Preliminary analysis of a subset of water samples (n=10) shows that the most frequently detected QACs are the BACs (C8, C10, C12 and C14) as well as C10 ATMAC, C12 ATMAC and C8/C10 DADMAC. The most abundant QACs at this time are C18 ATMAC, C18 BAC and C8 BAC with concentrations up to 14.59, 7.96 and 5.17 ng/L, respectively. These preliminary results demonstrate that QACs are present in the bay water and the risk screening for the surrounding aquatic life is currently being conducted.

5.04.T-06 Sex-Specific Gut Microbiome Dysbiosis in Fathead Minnows Exposed to Benzalkonium Chloride: A Multi-Scale Assessment From Controlled Exposure to a Whole-Lake Experiment

Milena Esser[1], Raina Hubley[2], Denina Simmons[2], Lauren Timlick[3], Jose Luis Rodriguez Gil[3] and Karen Kidd[1] (1)McMaster University, (2)Ontario Tech University, (3)International Institute for Sustainable Development (IISD)

Quaternary ammonium compounds (QACs) are widely used antimicrobial chemicals in household, industrial, and institutional products, with benzalkonium chlorides (BAC) being one of the most commonly used members of this class. Environmental concentrations of BAC have been rising sharply following the 2016 FDA ban of 19 antimicrobial ingredients, and the subsequent increase in disinfectant use during the COVID-19 pandemic. Given its broad-spectrum antimicrobial properties and persistence in aquatic environments, BAC poses a

potential risk to natural microbial communities, including the gut microbiomes of fish.
To investigate these impacts, we employed a multi-scale approach conducting a lab exposure study as well as a whole-lake experiment at the IISD Experimental Lakes Area (ELA), Canada. Under laboratory conditions, male and female fathead minnows (Pimephales promelas) were exposed to environmentally relevant concentrations (0.5-15 µg/L) of BAC for 28 days under controlled conditions. The whole-lake experiment extends this investigation to realistic field conditions, where BAC is being added to a whole-lake at a target concentration of 2 µg/L throughout the open-water. Fathead minnows were sampled in 2023 and 2024 to establish pre-exposure baselines in both the treatment lake and two reference lakes, with exposure sampling conducted in 2025 following a full season of BAC addition. Fish guts were assessed via 16S rRNA (V3V4) amplicon sequencing; whole-lake samples are currently being processed.
Under laboratory conditions, BAC-exposed males exhibited a significant shift in community composition, characterized by a reduction in Enterococcus species at concentrations as low as 0.5 µg/L. Enterococcus are established fish gut probiotics supporting growth, survival, and pathogen resistance, therefore, their loss may have significant consequences for host health. Female gut microbiomes showed no significant changes despite sharing a similar baseline community composition with males. This differential response suggests that gut dysbiosis may be a secondary effect of broader sex-specific physiological responses to BAC. These findings demonstrate sex-specific gut dysbiosis in fathead minnows at concentrations routinely found downstream of wastewater treatment plant effluents. The multi-scale design of this study will allow us to assess whether these effects occur under environmentally realistic conditions and whether they translate into population-level effects.

Antimicrobials in the Environment: Chemistry, Fate and Ecotoxicity

5.04.P-We247 Higher Susceptibility of Cyanobacteria to Certain Antimicrobials Compared With the Standard Green Alga, Raphidocelis subcapitata

Noriaki Namba[1], Yusuke Oda[1], Haruna Watanabe[1], Takahiro Yamagishi[1], Kyoshiro Hiki[2], Tomoko Sugiura[1], Akiko Nagao[3], Koichi Ohno[1] and Hiroshi Yamamoto[1] (1)National Institute for Environmental Studies (NIES), (2)University of Tokyo, (3)National Institute for Environmental Stuides (NIES)

While the environmental fate and transport of antimicrobial resistance (AMR) genes have become emerging concerns in Japan, the ecological risks posed by antimicrobials themselves remain significant, as they are among the micropollutants with the highest ecological impact in surface waters. Our research group has long focused on the ecological risks of more than 100 pharmaceuticals, including antimicrobials, in Japan, and we have found that algae are generally the most susceptible group among the standard aquatic test organisms, including fish, crustaceans, and algae, used for ecological risk assessment.
Subsequently, we conducted a study on species sensitivity differences based on a comprehensive literature survey, and found that specific antimicrobials, particularly cell envelope inhibitors, can cause toxicity in cyanobacteria at lower concentrations than the standard green alga, Raphidocelis subcapitata. This finding suggests that cyanobacteria may be underrepresented in current ecological risk assessment frameworks for certain antimicrobials.
Thus, we conducted algal growth inhibition tests for a wide range of antimicrobials, including β-lactams, using selected cyanobacteria, Cyanobium sp., Synechococcus leopoliensis, and Anabaena variabilis, in conformity with OECD Test Guideline No. 201 (the revised version adopted by the OECD in 2026). The preliminary

results suggest sensitivity differences among both cyanobacterial species and antimicrobials.
These results indicate that cyanobacteria exhibit diverse responses that cannot be fully captured by standard algal species alone. Therefore, future research should include comprehensive high-throughput screening across diverse cyanobacterial taxa to identify sensitive species and to clarify the underlying causes of sensitivity differences based on morphological, physiological, and genomic characteristics.

Disclaimer/Disclosure: This research was supported by the Environment Research and Technology Development Fund (JPMEERF25S21230) of the Environmental Restoration and Conservation Agency (ERCA), provided by the Ministry of the Environment of Japan.

5.04.P-We249 Zinc Compounds Drive Plasmid-Mediated Antimicrobial Resistance Gene Transfer in Poultry-Associated Escherichia coli

Haijiao Lin[1], Mohamed El-Fateh[1], Charles Viau[1], Sara Malik-Vidal[1], Hafiz Muhammad Arfan[1], Jianguo Xia[1] and Xin Zhao[1] (1)McGill University

Poultry-associated pathogens and commensal bacteria frequently harbor antimicrobial resistance genes, many of which are plasmid-borne. Plasmid-mediated horizontal gene transfer is a major mechanism driving antimicrobial resistance dissemination. Although antibiotics and heavy metals can induce plasmid conjugation, the contribution of non-antibiotic feed additives, particularly zinc oxide nanoparticles and zinc sulfate, to antimicrobial resistance gene transfer remains poorly understood. This study investigated whether zinc oxide nanoparticles and zinc sulfate enhance plasmid-mediated conjugation in poultry-associated Escherichia coli and explored the potential role of oxidative stress.

Escherichia coli isolates were recovered from fecal samples collected from commercial poultry farms where antibiotics were not used for growth promotion. In vitro conjugation assays were performed using poultry-associated Escherichia coli isolates as donors and plasmid-free Escherichia coli 6841 as the recipient. Zinc-mediated plasmid transfer was further evaluated using an in vivo Caenorhabditis elegans model. Intracellular reactive oxygen species were measured after zinc exposure, with or without the reactive oxygen species scavengers N-acetyl-L-cysteine and thiourea.

Plasmids were detected in 48 Escherichia coli isolates, of which 39 were resistant to at least one tested antibiotic, including ampicillin, nalidixic acid, chloramphenicol, streptomycin, or tetracycline. A representative donor isolate successfully transferred plasmids to the plasmid-free recipient strain in vitro. Exposure to zinc oxide nanoparticles and zinc sulfate significantly increased conjugation frequency in a dose-dependent manner. Plasmid transfer was also confirmed in the Caenorhabditis elegans model, where transconjugants exhibited combined resistance phenotypes derived from both donor and recipient strains. Zinc exposure was associated with oxidative stress, and reactive oxygen species scavengers reduced zinc-enhanced conjugation frequencies.

These findings indicate that zinc compounds can enhance plasmid-mediated antimicrobial resistance gene transfer in poultry-associated Escherichia coli, potentially through oxidative-stress-associated mechanisms. This study highlights the need to consider the ecological consequences of non-therapeutic zinc-based feed additives and their potential contribution to unintended antimicrobial resistance dissemination in agricultural systems.

Disclaimer/Disclosure: The authors declare no conflicts of interest.

5.04.P-We251 Environmentally Relevant, Chronic Benzalkonium Chloride Exposure Impacts the Fathead Minnow (Pimephales promelas) Proteome

Raina Hubley[1], Theresa Warriner[1], Eva Cyril[1], Jose Luis Rodriguez Gil[2], Karen Kidd[3] and Denina Simmons[1] (1)Ontario Tech University, (2)International Institute for Sustainable Development (IISD), (3)McMaster University

Benzalkonium chloride (BAC) is an antimicrobial compound often integrated into household personal care products, surface cleaners, antimicrobial clothing, and cosmetics. When these chemicals are released into surface waters they become a threat to aquatic species. Although researchers have identified BACs in environmental water samples at µg/L concentrations, few studies have examined their toxicological effects on fish. When fish are exposed to contaminants, they may develop molecular changes within their tissues and biofluids. Scientists use proteomics to determine the effects of contaminants on protein abundance and examine potential protein biomarkers that are tied to adverse outcome pathways. We determined the effects of BAC on the fathead minnow (Pimephales promelas) proteome by exposing 264 mixed-sex, mature fathead minnows to environmentally relevant concentrations of a BAC mixture (0.5, 1, and 15µg/L) and solvent control (0µg/L) over a 28-day period. Following the flow-through exposure, we anaesthetized fish with 100 mg/L buffered tricaine methanesulfonate to collect biofluid and tissue samples. Next, proteins were sequenced with liquid chromatography-tandem mass spectrometry (LC-MS/MS). In this presentation, we will highlight the plasma, gill, liver, and mucus proteomics results. Liver samples collected from the BAC-exposed fish had the highest proportion of significantly impacted proteins. Our preliminary findings suggest that BAC-exposed fish developed impacted proteins related to neurotoxicity, pulmonary toxicity, and inflammation. We found that there was no significant sex-bias due to BAC exposure. The present study supports an ongoing whole-lake, multi-year BAC exposure at the International Institute for Sustainable Development-Experimental Lakes Area.

5.04.P-We252 Antimicrobial-Resistant Bacteria in Caddisfly Larvae Upstream and Downstream of Wastewater Treatment Plant Effluents

Milena Esser[1], Julia Neglia[1], Allan Artavia[1], Cameron Currie[1] and Karen Kidd[1] (1)McMaster University

Antimicrobial resistance (AMR) is a global public health crisis increasingly recognized as a One Health issue requiring integrated surveillance across human, animal, and environmental compartments. Wastewater treatment plants (WWTPs) are known hotspots for AMR dissemination into receiving water bodies, yet little is known about whether AMR develops within the microbiome of aquatic insects, or their potential role in transferring resistance into terrestrial ecosystems through emergence.

In this study, bacteria were isolated from caddisfly larvae (Hydropsychidae) collected up- and downstream of 2 WWTP effluent discharges in Ontario, Canada. Larvae were homogenized and plated on non-selective media, and resulting colonies were isolated before identification by MALDI-TOF mass spectrometry. Antimicrobial susceptibility to 11 antibiotics representing 8 classes (penicillins, cephalosporins, carbapenems, fluoroquinolones, aminoglycosides, tetracyclines, phenicols, folate pathway antagonists) was determined using the Kirby-Bauer disk diffusion test, with breakpoints applied according to current CLSI and EUCAST guidelines.

Multiple isolates were identified from larval homogenates, including Aeromonas, Serratia, and Bacillus as the

predominant genera. Multidrug-resistant organisms (MDR; defined as resistance to ≥3 antibiotic classes) were detected at both upstream and downstream sites, with resistance to cephalosporins, penicillins, and tetracyclines most commonly observed among MDR isolates. Notably, reduced susceptibility to meropenem, an antibiotic of last resort, was detected in Aeromonas isolates, though whether this reflects intrinsic or acquired resistance warrants further investigation. Furthermore, differences in resistance profiles and MDR prevalence were observed between up- and downstream sites, suggesting that WWTP effluent may contribute to AMR burden in the larval caddisfly microbiome, though further tests will be needed to confirm this pattern. Analyses are ongoing across larvae from multiple sites as well as adult caddisflies and riparian spiders, to investigate whether AMR bacteria acquired during the aquatic larval stage persist through metamorphosis and are subsequently transferred to terrestrial predators. If confirmed, this would represent a previously overlooked pathway for AMR dissemination from anthropogenically impacted freshwater systems into terrestrial food webs, with implications for One Health surveillance frameworks.

5.04.P-We253 Transcriptomic Responses of Wild Lake Trout (Salvelinus namaycush) to Ecosystem-Scale Benzalkonium Chloride (BAC) Exposure

Maycie McWillie[1], Lauren Timlick[2], Lee Hrenchuk[2], Francisco Carlos da Silva[1], Julie Borsa[1], Jose Luis Rodriguez Gil[2], Karen Kidd[3], Natacha Hogan[1] and Markus Hecker[1] (1)University of Saskatchewan, (2)International Institute for Sustainable Development (IISD), (3)McMaster University

Benzalkonium chloride (BAC) is a widely used antimicrobial agent and an emerging contaminant of concern due to incomplete removal during wastewater treatment and consequent pseudo-persistence in aquatic environments. In fish, BAC induces toxicity through non-specific membrane disruption, particularly affecting gill function and ion regulation; however, its ecosystem-level effects under environmentally relevant conditions remain poorly understood. To address this knowledge gap, a multi-year whole-lake experiment is underway at the Experimental Lakes Area in northwestern Ontario, where BAC is applied to a treatment lake targeting an environmentally-relevant nominal concentration of 2 µg/L within a before–after control–impact (BACI) design. Specifically, we are evaluating sub-lethal transcriptomic responses of lake trout (Salvelinus namaycush) using minimally invasive tissue sampling coupled with whole transcriptome RNA-sequencing. Adult lake trout were caught via angling in spring and fall of 2024 (pre-exposure) and 2025 (post-exposure) from treatment and reference lakes. Caudal fin clips and whole blood were sampled non-lethally and used to (1) quantify baseline transcriptomic variation across sex, season, tissue type, and lake, and (2) identify differential gene expression associated with whole-lake BAC exposure. Morphometric measurements (e.g., total length, weight) were also collected to assess potential condition factor changes linked to altered food web structure. Preliminary analyses indicate clear baseline differences in gene expression between treatment and reference lakes, with comparatively limited divergence between sexes, highlighting the importance of baseline context in interpreting BAC responses. Additional transcriptomic analyses are ongoing. We hypothesize that BAC exposure will induce transcriptomic changes in lake trout that could reflect both direct exposure and indirect influences mediated by bottom-up ecological mechanisms. It is anticipated that this study will help bridge molecular and ecosystem-scale responses to BAC and support non-lethal transcriptomic biomarkers as scalable tools for long-term environmental monitoring.

Biologics in Agriculture: Improving Testing and Risk Assessment to Bring Biological

Solutions to Growers

5.05.P-We011 Addressing Methodological Challenges in Microbial Pesticide Testing: Insights From an OECD Survey To Inform Non Target Organism Guidance

Lisa Ortego[1], Shannon Borges[2] and Bilgin Karaoglan[3] (1)Bayer Research & Development Services LLC, (2)U.S. Environmental Protection Agency (US EPA), (3)German Environment Agency (UBA)

Microbial pesticides present distinct challenges for environmental risk assessment due to their biological complexity and limited applicability of chemical-based test guidelines. As part of an OECD initiative to develop new non-target organism guidance, a global survey was conducted to identify key testing challenges and inform early guidance development.

Respondents (n ≈ 76) represented industry, regulatory agencies, and research organizations, with more than 70% reporting over five years of experience in microbial pesticide testing. Familiarity with major regulatory frameworks, including those in the EU and United States, was high.

Key findings revealed persistent inconsistencies in study design and interpretation. Negative, sterile filtrate, and attenuated controls are widely used, but interpretation is complicated by modifications to test materials (e.g., autoclaving effects). Positive controls are predominantly chemical, reflecting the absence of suitable microbial comparators. Dose verification relies primarily on plate counting, with increasing interest in molecular approaches such as qPCR to address variability and non-culturable fractions.

Across aquatic and terrestrial systems, challenges include turbidity, variability in exposure regimes, and difficulty distinguishing toxicity from pathogenicity. Exposure estimates are commonly based on simplified application-rate approaches, highlighting the need for improved modeling tools.

Overall, responses highlight the need for harmonized, microbiologically relevant guidance. Findings from this OECD effort directly inform development of fit-for-purpose non-target organism guidance, including considerations on improved control design, options for dose verification, and approaches to assess infectivity, pathogenicity, and environmentally realistic exposure.

5.05.P-We012 Enabling Innovation While Protecting Health: A Science-Based Framework for Genome-Edited Microorganisms

Lisa Ortego[1], Leah Zorrilla[1], Lisa Baker[2], Rodolphe Barrangou[3], Leah Buchman[4], Amy Grunden[3], Priyanka Kudalkar Gurdasani[5], Nicole Juba[6], Chris Peterson[7], Lauren Stutts[3] and Danesha Seth Carley[3] (1)Bayer Research & Development Services LLC, (2)Corteva Agroscience, (3)NC State University, (4)Novonesis, (5)Mosaic Biosciences, (6)North Hill Group, (7)Peterson Global Agriculture Development

The rapid advancement of genome-edited microorganisms (GEMs) for agricultural use is outpacing the development of fit-for-purpose regulatory frameworks. Existing biotechnology regulations, largely derived from plant and chemical paradigms, often rely on classifications based on the presence of “non-native” genetic material rather than the functional characteristics of the microorganism. In the microbial context—where horizontal gene transfer and dynamic genome evolution are common—such classifications may not accurately reflect biological reality nor inform proportional regulatory oversight.

Global regulatory approaches for GEMs remain fragmented, with substantial variability in how jurisdictions define, assess, and regulate these products. In many cases, regulatory triggers are tied to genetic novelty, leading to increased data requirements and barriers to field testing and commercialization, even when functional

risk is comparable to that of well-characterized wild-type strains.
A science-based regulatory framework for GEMs should prioritize microbial function, ecological behavior, and hazard potential over genetic classification alone. Advances in tools such as whole-genome sequencing, weight-of-evidence approaches, and new approach methodologies enable more targeted and efficient safety evaluations that are better aligned with microbial biology.
Within this context, risk assessment remains a critical, supporting component of regulatory decision-making. For microbial products, regulatory experience demonstrates that hazard identification (e.g., pathogenicity, toxigenicity, and antimicrobial resistance potential) often effectively rules out significant risk, while environmental fate and exposure data are more difficult to generate, interpret, and standardize due to the lack of established testing guidelines.
Emerging evidence from agricultural systems suggests that many genome-edited microbes exhibit environmental behavior similar to their wild-type counterparts, reinforcing the need for proportionate, function-based regulatory approaches. Collectively, these insights highlight the urgency of developing harmonized, science-driven regulatory frameworks that enable innovation while maintaining protection of human and environmental health.

5.05.P-We013 Evaluation of Bacillus Subtilus on Nitrification Using the Standardized OECD 216 Guideline

Tyler Jacinto[1], Roxanne Brackett[1] and Sean McLaughlin[1] (1)Smithers LLC

Microbial-based pesticides have become a significant source of agricultural products registered on the worldwide market to control agricultural pests. Some sources report up to 400 microbial pesticide products in use across the globe. Like all pesticide products that are registered for crop protection, they all must be evaluated for their potential effect on the natural environment through an environmental risk assessment (ERA). Experimental test guidelines outline methods to produce the endpoints needed to fulfill environmental risk assessments. Since the ERA process is still relatively new in relation to the recent microbial products coming onto the market, this is an important point in time to reflect on the current testing requirements for biological pesticides in general.
The study we propose to conduct is a standard Soil Microorganism - Nitrogen Transformation Test with a formulated microbial pesticide containing Bacillus subtilus. This is a test to assess if there is any inhibition in nitrate formation over a 28 period by the test substance. Literature indicates that microbial pesticides should enhance soil health and uptake of nutrients. This experiment aims to verify if the standard OECD 216 will produce a similar conclusion and if such a test should be considered when conducting an ERA for a microbial crop protection product.

5.05.P-We014 Considerations for the Validation of Analytical Methods for Microbial Pesticides

Joshua Arnie[1], Sarah McCoy[1] and Hannah Stewart[1] (1)Eurofins Agroscience Services US

The global agricultural market for biologicals is anticipated to grow by 12% CAGR through 2030 with its market size increasing from 18 billion to 30 billion over that period. Most ecotoxicity studies conducted under either OECD and/or OCSPP guidelines call for verification of dosing and assessment of stability of the test item

in the test system. Conventional chemicals can be assessed with traditional analytical methods, however, microbial pest control agents (MCPAs) require a different approach, whether through plating or molecular methods. Existing guidance for analytical method validations in support of ecotoxicity testing to meet OECD and OCSPP guidelines is based upon conventional chromatographical methods (SANTE/2020/12830, Rev 2. 2023). This guidance explicitly states it is not intended for biological agents. This creates an appreciable and increasing gap between demand for biological products in agriculture and a lack of clear guidance on the conduct and evaluation of analytical methods validations for these products.

Here, we compare conventional chemicals and proposed best practices for biologics to meet precision, accuracy and repeatability criteria for SANTE guidance. Where possible, best practices used to meet SANTE guidance will be compared against U.S. EPA Microbiological Methods of Analysis (FEM 2009). Special considerations will also be made in regard to different test systems and matrices, with a discussion on appropriate controls and standards.

5.05.P-We015 The Use of Painted Lady Butterflies (Vanessa cardui L.) as One of the Non-Target Insects for Microbial Pesticides Registration

Michael Patnaude[1] (1)Smithers

With the increasing growth of developing and producing microbial pesticides, non-target insect test methods are needed for regulatory review and risk assessment of these products. There are no standardized test methods for representatives of the Order Lepidoptera to evaluate potential risks despite the number of target lepidopteran crop pests and the fifty lepidopteran species listed in the Endangered Species Act. The painted lady butterfly, Vanessa cardui (Lepidoptera: Nymphalidae), is a suitable test organism due to its worldwide distribution, ease of culturing, and ability to consume an artificial diet. A parasitic wasp is commonly used as one of the tests to meet the EPA microbial guidelines (OPPTS 885.4340), but more test organism diversity would be beneficial as honey bees (another hymenopteran) are often included in the test roster. An overview of the test methods following the EPA microbial guidelines (OPPTS 885.4340) using V. cardui will be discussed. Preliminary trial data with a representative microbial product will also be included as well as a reference toxicant to indicate relative sensitivity compared to other commonly tested non-target insects (i.e. Coleomegilla maculata and Chrysoperla rufilabris).

5.05.P-We016 Perspective on Standardizing the Assessment of Microbial Contaminants in Biopesticides

Sarah McCoy[1], Joshua Arnie[1], Sreedevi Govindu[1] and Hannah Stewart[1] (1)Eurofins EAG Agroscience

Biopesticides are a group of naturally derived plant protection products that are presumed to be less toxic and more targeted alternatives to synthetic pesticides. They are increasingly used as a key component of sustainable agriculture and in integrated pest management programs. Biopesticides are a diverse group of products that include; biochemical pesticides, microbial pesticides and plant-incorporated protectants. A significant proportion of Biopesticides are manufactured through fermentation processes that have the potential to produce unintended microbial contaminants of concern, such as human pathogens. Product characterization is a requirement for regulatory submission which includes demonstrating that potential pathogens of concern are not

present, either by a description of quality control measures or targeted analysis for potential contaminants in 5 production batches. However, the target contaminants, detection methods and limits of detection are not well defined in regulatory guidance. Here, we propose a harmonized approach for assessing microbial contaminants in biopesticide products by integrating principles from the OECD Issue Paper on Microbial Contaminant Limits for Microbial Pest Control Products which provides framework for identifying relevant contaminant groups and interpreting acceptable limits, the U.S. EPA Series 885 microbial pesticide test guidelines, and the FDA Bacteriological Analytical Manual (BAM) which offers well-established analytical approaches for detection, enumeration, and confirmation of key microbial indicators and pathogens. This harmonized approach emphasizes standardized sampling, validated culture-based and enumeration methods, acceptable limits of contamination and presumptive organism identification. By aligning product characterization, contaminant screening, and confirmatory testing with established regulatory expectations, this framework supports greater consistency in laboratory practice, improves comparability of data across labs, and strengthens confidence in data submitted for regulatory purposes.

5.05.P-We017 Understanding the United States Agricultural Biologics Landscape Through Biopesticide Registrations and Environmental Risk Assessment Considerations

Kursten Spegar (Anderson)[1] and Sian Ellis[2] (1)Corteva Agriscience LLC, (2)Corteva Agriscience UK Limited.

Agricultural biologics are playing an increasingly role in crop protection and plant health management in the United States (U.S.). These products span a wide range of active ingredients, modes of action, and environmental behaviors, especially with novel biocontrol modalities being introduced to the market such as dsRNA and peptides.

This review examines biopesticides registered by the U.S. Environmental Protection Agency Biopesticides and Pollution Prevention Division over the past 10 years to develop a broad picture of the agricultural biologics landscape in the United States. Registrations were grouped by product category (e.g., insecticides, fungicides, microbial products, etc.), to explore how different biological tools are represented within the regulatory space. The review also considers factors such as mode of action and intended use pattern, with selected examples used to look more closely at how data requirements have been addressed in practice. Emphasis is placed on ecotoxicology and environmental fate considerations, including the acceptance of weight of evidence approaches, higher-tier testing, and supplementary information such as environmental persistence, microbial viability, or other exposure-relevant data in supporting the conclusion of safe use. Examining how biological products have been evaluated in practice may help identify opportunities to refine regulatory approaches and support fit-for-purpose environmental assessments.

Overall, this work aims to provide a structured perspective on the U.S. biologics registration landscape, improve understanding of the expanding suite of tools available to U.S. growers and offer insights into how environmental risk assessment approaches are being applied across substance types.

Bridging the Gap: Integrating AI, New Approach Methodologies and Novel Toxicity Endpoints for Next-Generation Risk Assessment

5.06.T-02 Enzyme-Aware Transformers as a New Approach Methodology for Next-Generation Risk Assessment

Joerg Wicker[1], Liam Brydon-Brown[2], Tim Lorsbach[1] and Tobias Olenyi[1] (1)enviPath, (2)University of Auckland

Predicting how chemicals transform in the environment is central to assessing their persistence and the hazard posed by their transformation products, endpoints increasingly demanded by regulation, which now requires biodegradation modeling for the approval of novel chemicals. Yet the laboratory studies that generate this evidence are slow and costly, motivating New Approach Methodologies (NAMs) that predict biotransformation in silico.

Environmental degradation reactions are predominantly enzyme-catalyzed, and the enzyme class, defined by its Enzyme Commission (EC) number, largely dictates which reaction occurs. Most AI reaction predictors ignore this context, relying on compound structure alone, while methods that do incorporate enzymes assume the catalyzing class is already known. In complex biodegradation settings, it rarely is. Approaches that infer the enzyme from a complete reaction create a circular dependency: predicting the product requires the enzyme, and predicting the enzyme requires the product.

We break this dependency with ECLIPSE (Enzyme Class Learning and Interaction Prediction SystEm), which predicts the EC number(s) a compound is likely to interact with directly from its structure, before any product is known. ECLIPSE trains a hierarchical multi-label classifier, an automatically tuned XGBoost model at each node of the EC hierarchy, and achieves a hierarchical F1-score of up to 93.2%, outperforming existing methods.

We then condition a transformer-based product predictor on ECLIPSE's EC numbers and benchmark three regimes (no enzyme context, true EC numbers, and ECLIPSE-predicted EC numbers) on EAWAG-BBD biodegradation data. This quantifies how enzyme context improves transformation-product prediction and how errors propagate through the pipeline.
Together, ECLIPSE and enzyme-aware product prediction form an AI-driven NAM that maps a chemical's metabolic fate from structure alone, generating the transformation products and pathways on which downstream toxicity endpoints depend. It bridges machine learning and regulatory practice to support faster, animal-free, next-generation risk assessment.

5.06.T-04 Using Electrophysiology To Explore How Fish Respond to Changes in Water Quality: Insights From the Gill and Olfactory Epithelium

Lauren Zink[1], Steve Wiseman[1] and Chris Wood[2] (1)University of Lethbridge, (2)University of British Columbia

Water quality is constantly changing due to alterations in land use, climatic shifts, and other factors. Numerous researchers have noted that some aspects of water quality such as dissolved organic carbon (DOC) are beneficial at the gill while others such as pollution from microplastics have a negative effect. We can utilize electrophysiological techniques to provide a high-throughput understanding of the physiological response to these changes. At the gill, we can utilize transepithelial potential (TEP), which is the diffusion potential

between the blood plasma and ambient water, primarily due to the differential permeabilities of sodium and chloride across the gill epithelium. While the gill serves as the primary site for gas exchange, osmoregulation, acid-base regulation, and ionoregulation, we have learned that the response of the gill to a change in water quality (such as DOC) is not indicative of the response at other sensory tissues, such as the olfactory epithelium. Fish rely on olfactory perception to mediate a range of crucial life-history behaviours such as predator avoidance, navigation, and foraging. Olfactory detection occurs when an odourant binds to a receptor in the olfactory epithelium, initiating a signaling cascade that depolarizes a neuron resulting in an action potential. Bulk measurements of the electrical activity of cellular depolarization at the olfactory epithelium can be measured by electro-olfactography (EOG). The EOG response is indicative of olfactory acuity (i.e., how well a fish can smell). Changes in water quality, such as temperature, can heighten olfactory acuity while others such as increased metal concentration can dampen EOG responses. This presentation will highlight the versatility for using electrophysiology when investigating changes in water quality and its usefulness in deconstructing complex responses by fish in changing environments (NSERC).

5.06.T-05 Computational and In Silico Risk Assessment of N-Nitrosamines Derived From Industrial and Agricultural Amines

Samira Norouzi[1] and Xianming Zhang[1] (1)Concordia University

Amines are widely used chemicals in pharmaceutical, agricultural, and industrial applications. In certain environmental conditions, amines may undergo nitrosation to form N-nitrosamines. N-nitrosamines can be activated by cytochrome P450 enzymes in the body, creating reactive intermediates that may bind to DNA and cause mutations or cancer. Although some N-nitrosamines have been well studied, the cancer risk of many others is still unknown. While structural features influence N-nitrosamine bioactivation and carcinogenicity, the role of substituent (R) groups remains poorly understood. Because R-group substitutions can affect the formation of reactive metabolites, understanding these structure–activity relationships is important for predicting the carcinogenic potential of untested N-nitrosamines. This study aims to evaluate how various R-group substitutions affect the toxicological behavior and potential carcinogenicity of N-nitrosamines. A wide range of amine compounds from both industrial and agricultural sources was evaluated. Compounds were screened based on predicted nitrosation potential, liver exposure, and affinity for cytochrome P450 enzymes. We used the httk package in R for High-throughput physiologically based toxicokinetic (PBTK) modeling, and OpenEye software for molecular docking. Promising candidates were then evaluated using molecular dynamics (MD) and density functional theory (DFT) calculations. Of 3740 amines screened, 1607 were more likely to undergo nitrosation. Among these, 937 compounds had at least one α-hydrogen and were given priority, since cytochrome P450-mediated α-hydroxylation is the main bioactivation pathway linked to the carcinogenicity of many N-nitrosamines. Compounds with the highest predicted liver exposure were selected for docking studies. Docking studies against CYP2E1 and CYP1A2 receptors showed a wide range of binding affinities among the selected compounds, with binding energy scores ranging from −5 to −14 kcal/mol. Several compounds were positioned with the α-hydrogen close to the heme iron, which is consistent with metabolic activation by α-hydroxylation. These results show that combining different prediction and computational methods can help identify N-nitrosamines with a higher likelihood of metabolic activation. Ongoing molecular dynamics, DFT, and experimental studies will further elucidate the relationships among molecular structure, bioactivation, and carcinogenic potential of N-nitrosamines.

Bridging the Gap: Integrating AI, New Approach Methodologies and Novel Toxicity Endpoints for Next-Generation Risk Assessment

5.06.P-We237 A Network of Adverse Outcome Pathways To Support the Use of New Approach Methods for Identifying Endocrine Hazards

Daniel Villeneuve[1], Travis Karschnik[2], John Frisch[2] and Scott Lynn[1] (1)U.S. Environmental Protection Agency (US EPA), (2)General Dynamics Information Technology

Adverse outcome pathways (AOPs) provide a framework for documenting a scientifically plausible, evidence-based, connection between biological activities measured in vitro, or at low levels of organization in vivo, to hazards to individuals and/or populations that are of concern for risk assessment and regulation. Recently, the US Environmental Protection Agency (EPA) validated new approach methodologies (NAMs) for detecting estrogen receptor (ER) and androgen receptor (AR) activation. However, AOPs linking ER or AR activation to apical endpoints measured in tier 1 and tier 2 assays employed by the Endocrine Disruptor Screening Program (i.e., OCSPP 890.1600; 890.1400; 890.1450; 890.1500; 870.3800; 890.1350; OECD 443) were lacking. Consequently, a concerted effort was undertaken to develop AOPs documenting causal links between ER and AR activation and relevant reproductive and developmental endpoints to further support the use of NAMs in meeting EPA's statutory obligations. AOPs outlining mechanisms and evidence linking ER agonism or antagonism to endometrial carcinoma (AOP 167), prolonged estrous (AOP 609), vaginal cornification (AOP 623), increased uterine weight (AOP 637), precocious puberty (AOP 639), decreased fertility (AOP 640), impaired fish reproduction (AOP 30), and female biased sex ratios in vertebrates with environmental sex determination were developed. Additional AOPs linking AR activation to reproductive impairment in fish (AOP 23), male biased sex ratios in fish (AOP 376), and delayed preputial separation (AOP 619) were also developed to complement an extensive network of androgen signaling related AOPs contributed by investigators from Denmark. These AOPs are documented and disseminated in the AOP-Wiki and help document the relevance of NAMs for ER and AR activation to help identify substances potentially able to elicit adverse endocrine effects.

Disclaimer/Disclosure: The contents of this abstract neither constitute, nor necessarily reflect US EPA policy.

5.06.P-We238 A Standard Operating Procedure–Guided Knowledge Graph Framework for Traceable Adverse Outcome Pathway Evidence Retrieval

Shinjeong Hwang[1], Gaeul Yang[1], Heejin Kim[1] and Hosik Choi[1] (1)University of Seoul

AOP-based assessment and new approach methodology workflows depend on evidence scattered across pathway records, bioactivity assays, chemical-gene associations, phenotype annotations, and product-use data. In practice, the challenge is not only finding a relevant database record, but judging whether that record is usable for weight-of-evidence interpretation. An assay or chemical may be retrieved, while the supporting key event, activity value, source record, or link to an adverse outcome pathway remains missing.

We built a standard operating procedure-guided evidence review agent for toxicological review tasks where required evidence elements can be defined in advance. The agent uses domain review procedures as checklists for each question type. It retrieves evidence from an integrated toxicological knowledge graph, checks whether the expected elements are present, and reports missing or incomplete links.

For each use case, the agent records whether the evidence chain includes the expected AOP, key event, gene or

ontology term, assay result, activity value, and source information. The knowledge graph connects Adverse Outcome Pathway Wiki, ToxCast, the Comparative Toxicogenomics Database, the National Toxicology Program Integrated Chemical Environment, and product-use data.
We performed a preliminary evaluation with 270 toxicological questions covering nine evidence review tasks. Retrieved results were examined for evidence completeness, interpretable graph paths, and source traceability. Compared with less structured retrieval approaches that returned broad graph context or used procedure text only as general guidance, the agent better separated complete evidence chains from partial or unsupported results. It also made evidence gaps visible, including missing key-event links, unavailable assay measurements, and incomplete provenance.
The intended use is to assist AOP-based assessment, NAM interpretation, chemical prioritization, and transparent weight-of-evidence review. Rather than treating a database hit as a final answer, the agent reports what is supported, what is missing, and where further expert review or data curation is needed. Future work will add mechanistic directionality and reversibility-aware constraints to reduce evidence chains inconsistent with toxicological mechanisms before they influence interpretation.

Disclaimer/Disclosure: This research was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIT) (NO. RS-2022-NR068754).

5.06.P-We239 Reliability Evaluation of Fish Acute Toxicity Predictions Using the OECD QSAR Toolbox: Comparison of Individual and Ensemble Approaches

AEJIN KIM[1], KYUNGHEE JI[1] and SUJIN LEE[2] (1)Yongin University, (2)Korea Research Institute of Chemical Technology (KRICT)

Aquatic toxicity data remain unavailable for many industrial and commercial chemicals, creating challenges for hazard assessment and regulatory decision-making. Quantitative structure–activity relationship (QSAR) models are increasingly used to support chemical evaluation; however, their predictive reliability must be assessed before regulatory application. This study evaluated the performance of the OECD QSAR Toolbox for predicting fish acute toxicity and compared individual and ensemble prediction approaches.
Experimental 96-h fish median lethal concentration (LC50) data were collected for substances classified as Aquatic Acute Category 1 in the Korean hazard assessment database. Fish acute toxicity was predicted using three OECD QSAR Toolbox approaches: Read-across, QSAR, and Trend Analysis. Predictive performance was evaluated using coverage, prediction error, agreement with experimental data, sensitivity, and miss rate. An ensemble approach integrating all three prediction methods was also examined.
Among the individual approaches, the QSAR model showed the highest predictive performance but was limited in prediction coverage. Read-across and Trend Analysis exhibited lower accuracy and higher miss rates. The ensemble approach improved both prediction coverage and accuracy, achieving greater agreement with experimental toxicity data and enhanced identification of highly toxic substances. Nevertheless, prediction failures remained for certain chemicals, particularly those containing metal atoms or structural features outside the model applicability domain.
Overall, ensemble-based approaches improved the reliability and applicability of OECD QSAR Toolbox predictions compared with individual methods. However, uncertainty remains for specific chemical classes, highlighting the need for complementary experimental validation. These findings provide a scientific basis for prediction-based hazard assessment, chemical prioritization, and the regulatory application of alternative

assessment methods

Disclaimer/Disclosure: This study was supported by the 2026 Environmental Health Professional Training Program funded by the Ministry of Climate, Energy and Environment through the Environmental Health Center at Seokyeong University.

Centering Indigenous Knowledge in SETAC Science

5.07.T-01 All Our Chemical Relations

Gunilla Öberg[1], M. Murphy[2] and Susan Chiblow[3] (1)University of British Columbia (UBC), (2)TRU, University of Toronto, (3)University of Guelph

The urgent need to reduce emissions of climate-changing gases and pollutants requires innovative approaches to chemical risk management. Forming sustainable environmental relationships for future generations is at the heart of Indigenous approaches to caring for land, waters, air, and each other. “All Our Chemicals Relations”, which is a new, Indigenous-led, six-year-long project funded by Canada’s New Frontiers in Research Fund (NFRF), brings Indigenous research methods to this challenge to boldly transform chemical risk management in four arenas: 1) Indigenous community-based practice, 2) university labs and classes, 3) regulatory practices, and 4) policy development. Our initiative brings together Indigenous leaders, Elders, Indigenous and non-Indigenous researchers, and government partners from Canada and Aotearoa to reimagine how chemical risks are understood and managed. We aim to advance chemical risk management with the powerful insights of Indigenous expertise derived from acting as effective environmental stewards for thousands of years.

This presentation will provide an overview of the larger project and present lessons learned from our experiences as we set out to develop educational materials for government staff and university researchers. We will discuss challenges in helping non-indigenous people recognize and address ethical dilemmas when collecting data relating to Indigenous Peoples and their lands.

5.07.T-02 Privileging Māori Knowledge for Enhanced Research Outcomes

James Ataria[1], Nikki McRobie[1], Miricara Kawe[1], Louis Tremblay[2], Karen Fisher[3] and Dean Whaanga[1] (1)Te Ao Marama Inc., (2)Mannaki-Whenua Landcare Research, (3)University of Auckland

The convergence of political conservatism and neoliberal development agendas is accelerating the Anthropocene crisis by driving climate change, biodiversity loss, and deepening societal inequities at a global scale. Against this backdrop, Indigenous ‘knew’ knowledge offers a credible and urgent alternative – an epistemological framework that situates humans within, rather than above, the ecosystem, and that foregrounds balance, reciprocity, and inter-generational thinking. Yet privileging these knowledge systems and amplifying Indigenous aspirations within contexts dominated by prevailing political, commercial, and academic paradigms remains a significant challenge. How do we move beyond tokenistic inclusion toward genuine systemic transformation? Here we present a case study of Indigenous research leadership in Aotearoa-New Zealand in which Indigenous project governance, co-development, and co-generation have fundamentally reoriented the

relationship between Indigenous knowledge and Western science. Rather than treating indigenous people's participation and knowledge as a supplement to scientific inquiry, this mission-led project has created institutional and relational conditions that center Indigenous authority – effectively "flipping the script" on conventional research programs where governance operational decisions and benefit are located outside of indigenous entities and communities. Drawing on critical reflections during the establishment of this project, we examine both the structural, inter-organizational and inter-personnel arrangements developed to onboard dual knowledge systems, sustain genuine partnerships and the strategies through which these were navigated. We posit that meaningful integration requires not just methodological innovation, but a willingness to redistribute epistemic power.

Disclaimer/Disclosure: This work is presented as part of the 'Towards Sustainable Futures: Transforming Chemical Risk Management with Indigenous Expertise' project that is sponsored by the Canadian Tri-Agency Institutional Program Secretariat: New Frontiers in Research Fund – Transformation (NFRFT-2024-00232)

5.07.T-03 Youth Engagement Initiatives and Opportunities Within a Community-Based Environmental Monitoring Program: Early-Career, Educator, and Youth Perspectives

Sophie Emberley-Korkmaz[1], Claudia Flynn[2], Serena Ionescu[2], Ryder Etienne[2], Alexa Fitzwilliam[1], Kailey Karahkwinéhtha Nicholas[3], Isabelle-Anne Bisson[4], Eugene Nicholas[3], Mary Nicholas[3] and Niladri Basu[1]
(1)McGill University, (2)Ratihén:te High School, Kanehsatà:ke Education Center, (3)Ratishontsanonhstats Kanesatake Environment, Mohawk Council of Kanesatake, (4)TerraHumana Solutions

Since 2019, the Environmental Contaminants and Health Impact Project (ECHIP) has been ongoing in the Mohawk Territory of Kanehsatà:ke (Kanesatake) through a collaboration between Kanesatake's Ratihontsanonhstats Environment team, McGill University, and TerraHumana Solutions. The project aims to better understand the potential environmental contaminants in samples collected throughout the community. Capacity building and community engagement have been central throughout the project, with recent efforts focused on youth outreach at Ratihén:te high school in Kanesatake. Youth play a vital role in environmental and health-related projects by contributing unique perspectives, valuable insights, and deep knowledge of their communities. We partnered with the school's science teacher to involve students in the research process through hands-on workshops and field- and lab-based activities from fall 2024 to present. These included presentations at the school by our team, training in environmental sampling, onsite sampling and recording fieldnotes, an ice-fishing event, and visits to the McGill lab where students conducted contaminant analyses on environmental and fish samples. Students also analyzed data from samples they collected, gaining direct experience in environmental monitoring and research. We present three perspectives on the successes and areas for improvement of this collaboration to highlight the importance of meaningfully engaging youth in community-based environmental projects. The first perspective is from a McGill PhD candidate on the ECHIP team who established the partnership, where the collaboration helped build relationships and encouraged the ECHIP team to reflect on how results and risks are communicated. The second is from the science teacher at Ratihén:te, who reflects on how having the students work with the ECHIP project as part of their classwork allowed them to see the connections between science in the classroom and applications in the community. The third is from two secondary 3 students, who both enjoyed learning about the work taking place in their community and contributing to efforts to monitor and protect the environment. We share this as an example of how researchers and community partners can engage youth in ways that strengthen projects and empower them to take an active

role in projects affecting their community. This work also emphasizes the importance of including youth when seeking to engage the broader community.

5.07.T-04 Quantifying per- and Polyfluoroalkyl Substances in Traditional Foods Across the Great Lakes Region: Manoomin (Wild Rice) and Psincinca (Broadleaf Arrowhead)

Eve Milusich[1], Gavin Dehnert[1], Emily Cornelius Ruhs[2] and Jessica Hua[1] (1)University of Wisconsin Madison, (2)Field Museum of Natural History

Per- and poly-fluoroalkyl substances (PFAS) are a class of emerging contaminants that pose risks to human, wildlife, and environmental health due to their persistence and tendency to bioaccumulate. Despite growing scientific, regulatory and public concern, limited information exists regarding PFAS bioaccumulation in many species harvested for human consumption, including traditional Indigenous foods. As PFAS contamination may pose disproportionate risks to Indigenous food sovereignty initiatives, understanding the potential presence of these contaminants in traditional foods is crucially important. This tribally-driven study investigates whether PFAS bioaccumulate in two previously unstudied aquatic plants and traditional foods: Manoomin (Ojibwe) (Wild Rice; Zizania palustris) and Psincinca (Dakota) (Broadlead Arrowhead; Sagittaria latifolia). Based on evidence of PFAS bioaccumulation in other aquatic plants, we hypothesized that both species would accumulate detectable levels of PFAS. Manoomin and Psincinca (n=3 plants per species, per site) were collected from three waterbodies across the Great Lakes region which represented a gradient range of PFAS contamination levels. Surface water and sediment samples were collected adjacent to sampled plants to determine potential plant uptake pathways from surrounding environmental matrices. All samples were analyzed for 40 targeted PFAS using EPA Method 1633A. In Psincinca, no PFAS were detected above the minimum level of detection. In Manoomin, four PFAS (perfluoro(2-ethoxyethane) sulfonic acid (PFEESA), perfluorohexane sulfonic acid (PFHxS), perfluorooctane sulfonic acid (PFOS), perfluoro-n-pentanoic acid (PFPeA)) were detected at variable levels in plant tissues (roots, stalks, and seeds). All detected concentrations were low (< 2 parts per billion) and unlikely to pose a risk for human consumption. To our knowledge, this study is the first to investigate PFAS bioaccumulation in Manoomin or Psincinca, and to quantify PFAS in Manoomin and surrounding environmental matrices. These findings highlight potential exposure pathways for harvesters and may help to inform Tribal food sovereignty initiatives. Furthermore, this study establishes a foundation for future research examining the impacts of PFAS on Manoomin health, and the broader well-being of aquatic ecosystems.

5.07.T-05 Healthy Waters: A Braided Approach That Identifies Pollution Priorities in British Columbia Watersheds

Peter Ross[1] and Kim Lagimodiere[2] (1)Raincoast Conservation Foundation, (2)Cowichan Tribes

Water pollution in British Columbia, Canada, threatens salmon, whales and people. Land-based pollution impacts fish habitat in freshwater environments, and contributes to as much as 80% of downstream ocean pollution – where Endangered (and highly-contaminated) Southern Resident killer whales feed. A complex backdrop of laws and regulations aimed at preventing pollution and protecting water, but legislation remains fragmented, government agencies operate in silos, and monitoring efforts are fragmented. We conducted high-resolution water pollution monitoring in 12 major watersheds where scientific expertise was applied through a lens of Indigenous Knowledge and local concerns. Five categories of water (source water, river water, road runoff, tap water and marine water) were sampled and analyzed for 587 contaminants from 11 priority

contaminant classes (metals, nutrients, polycyclic aromatic hydrocarbons, pesticides, alkylphenol ethoxylates, bisphenols, per- and polyfluoalkyl substances (PFAS), pharmaceuticals and personal care products, the tire-related chemical 6PPD-quinone, and sucralose). Samples are collected in wet and dry seasons over a two-year timeframe. Of these 587 analytes, only 36 (6%) have Health Canada Drinking Water Quality Guidelines, and just 43 (7%) have CCME Environmental Quality Guidelines, constraining our ability to evaluate risks to both humans and aquatic biota. The number of analytes detected in watersheds ranged from 94 to 135, averaging 105. Not surprisingly, the road runoff category consistently had the highest concentrations of most contaminants, with elevated metals, nutrients, PFAS and pharmaceuticals. Degradation of water quality was evident as water flowed downstream, and reflected forest fire smoke, agricultural runoff, septic and wastewater treatment plant discharges, road runoff, landfill operations and poor riparian zone protections. Our conclusions are enabling solution-oriented best practices in watershed communities. We are presently co-developing long-term, community-based water quality monitoring programs through the design of fact sheets, protocols and training modules. We aspire to create lasting capacity for the Land Guardians, Aquatics Staff and Indigenous community members who have a strong interest in understanding, protecting and restoring the lands and waters that have sustained Indigenous peoples for millennia.

5.07.T-06 Totally Tubular: An Evaluation of Contaminant Uptake by Wapato in a Tidal Wetland

Benjamin Johnson[1], Braedon Warner[1], Jenna DiMarzio[1], Caitlin Johnson[1], Sarah Greenfield[2] and Katie Daugherty[3] (1)GSI Water Solutions, Inc., (2)Oregon Department of Environmental Quality (DEQ), (3)Oregon Department of Environmental Quality

Historical wastewater discharges from industrial operations at a former wood products manufacturer in St. Helens, Oregon, have released contaminants and wood wastes to an adjacent wetland near Scappoose Bay (Site). Sagittaria latifolia (wapato) is present across both the Site and the Columbia River Basin. The tubers of this culturally important plant have been a traditional food source for the surrounding indigenous Tribes. The potential for wapato to uptake Site contaminants from surrounding sediments has gained attention in recent years as Tribes revive interest in the wapato harvest. The Oregon Department of Environmental Quality is currently implementing an Interim Removal Action Measure to remove impacted sediment and wood waste from a portion of the Site that poses the greatest risks to human health and the environment. Wapato tubers were collected from seven chemically distinct areas of the Site and an upstream background location. The tubers were processed and analyzed for arsenic, mercury, and dioxins/furans (the key Site contaminants). Arsenic was detected in all wapato tissue samples except for the background location and one area of the Site with lower sediment concentrations. Arsenic detections in Site wapato tissue were as high as 0.640 milligrams per kilogram, but linear correlations were not observed with sediment concentrations or percent lipids. Arsenic was generally not detected in tubers in areas with low sediment arsenic concentrations. These results indicate that wapato plants uptake more arsenic from the sediment into their tubers in contaminated areas than those in uncontaminated areas. Additional work may be pursued to evaluate bioavailability of contaminants within the tubers, or to confirm the relationship between sediment contaminants and tuber uptake after completion of the Interim Removal Action Measure, when wapato will be planted in newly placed, uncontaminated media as part of Site restoration.

Centering Indigenous Knowledge in SETAC Science

5.07.P-We165 The Evolution of the Environmental Contaminants and Health Impact Project (ECHIP): A Long-Term, Collaborative and Community Based Environmental Contaminants Research Project in Kanesatake

Alexa Fitzwilliam[1], Isabelle-Anne Bisson[2], Eugene Nicholas[3], Mary Nicholas[3], Sophie Emberley-Korkmaz[1], Kailey Nicholas[3], Kamryn McCallum[2] and Niladri Basu[1] (1)McGill University's Center for Indigenous Peoples' Nutrition and Environment (CINE), (2)TerraHumana Solutions, (3)Kanesatake Ratishontsanonhstats Environment

Concerns surrounding dumping in the Mohawk community of Kanesatake and associated reports of adverse health outcomes in the community prompted the development of the first community-led Environmental Contaminants and Health Impact Project (ECHIP) (2019-present). The overall research objectives are to a) increase understanding of chemical contamination in the community; and to b) investigate potential links between such contaminants and human exposure pathways (and ultimately with health concerns expressed by community members). Larger project aims include establishing a community-based monitoring program and increasing the capacity of the community to address contaminant issues. Here we provide an overview of ECHIP, an established soil, sediment, food, and water monitoring program where we collect samples three times per year (spring, summer, fall) from sites of concern designated in the early years of the project through preliminary scoping. Collected samples undergo metals analysis focused on chromium, cadmium, arsenic, nickel, lead, zinc, manganese, copper (varying between media type). We use risk quotient analyses using reference values from governmental regulatory bodies to assess contaminant risk. We aim to develop a community-accessible environmental contaminant data matrix and visualization platform to be used and run by the community. In addition to the technical aspects of the project, we aim to underscore the importance of aligning research practices with community priorities, timelines, and approaches to engaging with environmental issues. Through ECHIP, alternative approaches to knowledge sharing and engagement were explored, including community "kitchen table talks" held during the summer of 2025, which created more informal and accessible spaces for discussing environmental results and concerns. Finally, we address challenges facing long-term environmental monitoring initiatives, including stop-and-go funding support and limited local resources. This presentation will provide an overview of the ECHIP study, and include select results, as well as examples of knowledge translation and co-learning activities.

From Effect Models to Decisions: Integrating Effect Modeling into Regulatory Ecological Risk Assessment

5.08.P-Tu129 Assessing Population Relevance of Endocrine Disrupting Effects in Amphibians and Fish Using Population Models

Valery Forbes[1], Andreas Focks[2], Charles Hazlerigg[3], Udo Hommen[4], Brecht Ingels[5], Oliver Jakoby[6], Joachim Kleinmann[7], Laurent Lagadic[8], Katie Mintram[9], Erik Muller[10], Thomas Preuss[8], Melissa Reed[11], Benjamin Schreiber[12], Pernille Thorbek[7], Charles Tyler[13] and Lennart Weltje[7] (1)Florida Atlantic University (FAU), (2)University of Osnabrueck, (3)Enviresearch Ltd., (4)Fraunhofer Institute for Molecular Biology and Applied Ecology (IME), (5)FPS Health, Food Chain Safety and Environment, (6)RIFCON GmbH, (7)BASF SE, (8)Bayer Research & Development Services LLC, (9)Brunel University, (10)ibacon GmbH, (11)Health and

Safety Executive (HSE) - Chemical Regulation Division, (12)Austrian Agency for Health and Food Safety (AGES), (13)University of Exeter

The potential impacts of endocrine-disrupting chemicals (EDCs) on wildlife populations have been of concern for a number of years. For vertebrate wildlife, current legislation and guidance in the European Union (EU) severely restrict or prevent the use of EDCs, unless it can be demonstrated that their (individual-level) effects are not adverse at the population level. A recent review (Hazlerigg et al. 2025; https://doi.org/10.1093/inteam/vjae039) and an ongoing SETAC initiative (MAPPED - use of Models for Assessing PoPulation relevance of Endocrine Disrupting effects) address how population models can be used to determine the population relevance of endocrine-mediated effects of chemicals. This talk will provide an update on the status of the MAPPED initiative, highlight the distinct and common challenges for quantifying population relevance of endocrine disruption for amphibians and fish, and outline where future work is needed. Whereas an Adverse Outcome Pathway (AOP) framework is conceptually helpful for demonstrating how endocrine-disrupting mechanisms could plausibly result in whole organism and population impacts, limitations of current regulatory tests and a lack of information on key life stages add uncertainty. Fish are much more well studied than amphibians, with a large number and variety of published population models available. A number of alternative criteria are emerging for defining practical thresholds of acceptable/unacceptable population-level impacts. These need further discussion and agreement by the stakeholder community before they are ready for implementation in a regulatory context.

5.08.P-Tu130 Updates to Endangered Species Assessment Methodology for Pesticides

Frank Farruggia[1], Kristina Garber[1], Jennifer Connolly[1], Jerrett Fowler[1], Brian Gill[1], Ava Hanson[1], Marissa Liang[1], Meghann Niesen[1], Nathan Pollesch[1], Rebecca Prather[1], Cameron Rekully[1], Holly Rogers[1], Keith Sappington[1], Carolyn Schroeder[1], Sumathy Sinnathamby[1], Latasha Smith[1], Katherine Stebbins[2], Austin Wray[1] and Dirk Young[1] (1)U.S. Environmental Protection Agency (US EPA), (2)U.S. Environmental Protection Agency

The Environmental Protection Agency (EPA), Office of Pesticides Program has continued to evolve the tools, processes, and exposure assumptions used for evaluating non-listed and listed species since the release of the Endangered Species Act (ESA) strategies (i.e., Herbicide, Insecticide) and the Vulnerable Species Action Plan (VSAP). Assessing over 1,700 species and 900 designated critical habitats is resource intensive. With the development of the strategies, EPA is also refining some parameters and assumptions to (1) estimate more realistic exposure levels and (2) improve the scientific analyses for specific species to account for updated information and continued learning as we progress through ESA consultations with Fish and Wildlife Service and National Marine Fisheries Service and input through public comment processes.

EPA is also developing tools to more efficiently and consistently assess listed species. The developing tools include automations and new processes to expedite modeling and to increase consistency across the ESA assessment process. EPA plans to integrate terrestrial and aquatic models using a common interface for entering pesticide specific use patterns and toxicity endpoints. Ratios of exposure/toxicity will be calculated by taxon groups and compared to thresholds for assessing potential for effects. Similarly, species specific comparisons that incorporate species attributes (e.g., diet, habitat), risk modifiers, and spatial analyses, will be used to calculate the potential for impacts on individuals and populations of a listed species or critical habitat. Collectively, these tools provide the underlying analysis for making consistent and refined effects

determinations and to determine what mitigation may be needed to protect listed species, consistent with the strategies. This presentation will present highlights of these refinements and tools.

5.08.P-Tu131 Challenges in Using Dynamic Energy Budget Models To Support Ecological Risk Assessments

Roger Nisbet[1], Ferdinand Pfab[1], Alexandra Sexton[2], Louise Stevenson[3] and Cheryl Murphy[2] (1)University of California Santa Barbara, (2)Michigan State University, (3)Oak Ridge National Laboratory

A triad (DEBtox) of toxicokinetic (TK), toxicodynamic (TD), and Dynamic Energy Budget (DEB) modules has been advocated as a powerful approach for utilizing data from standardized toxicity tests for ecological risk assessment (ERA). Yet DEBtox has been used much less often than simpler TK/TD in applications. Here we explore the reasons for this. DEBtox enables ranking likelihood of different physiological modes of action (pMoA) for a stressor in terms of energy flows in a pre-selected DEB model. The importance for ERA is that different pMoAs impact population dynamics in different ways - prediction not offered by other approaches. The central challenge is that most DEB models use unobservable abstract variables and are consequently seriously over-parametrized even for "model" organisms. Typically, this challenge is ameliorated through additional assumptions on inter-specific co-variation of parameters, but DEB and DEBtox models remain data hungry: full parameterization let alone validation require through time measurements of endpoints relevant to growth and reproduction (and ideally survival) and many standardized toxicity testing methods do not require simultaneous measurements of multiple sublethal endpoints. Acceptance of TKTD models into ERA requires rigorous regulatory evaluation, and DEB's requirements are larger than other, "ready to be used" TKTD models for risk assessment.

DEBtox implementation utilizing full life cycle data (e.g. for Daphnia) requires: (i) estimation of DEB parameters for controls, ideally at multiple food levels; (ii) fitting treatments assuming different mechanism(s) of toxicity (i.e. different pMoA); (iii) using the Akaike information criterion (AIC) to identify most likely dominant pMoAs. This requires trustworthy parametrization of the control, especially the time course of energy input from feeding. We demonstrate this using data from a recent full life cycle study of the response of Daphnia magna to PFOS exposure. We show that pMoA identification is sensitive both to choice of DEB model (DEBkiss versus the standard version of the widely used DEB model by S.A.L.M. Kooijman) and to statistical methodology. Specifically, we advocate methodology that recognizes the possibility that there are different pMoAs at low versus high exposures. We conclude that DEBtox alone does not reliably identify pMoAs. We propose that the most promising way forward is to link the DEB modeling with molecular level data.

5.08.P-Tu132 Fish Individual-Based Models To Evaluate Population Relevance of Endocrine-Sensitive Apical Endpoints in Environmental Hazard Assessment

Alice Tagliati[1], Charles Hazlerigg[1], Laurent Lagadic[2], Edward Salinas[2] and Thomas Preuss[2] (1)Enviresearch Ltd., (2)Bayer AG Crop Science Research & Development

Population models have long been thought of as a suitable approach for assessing the population relevance of chemical effects observed on individuals in laboratory studies, although they have rarely been applied in a regulatory context. Typically, population models incorporate the sensitivity of species to chemicals, the mode of action and fate of toxicant in the environment, life-history traits of the species of concern, and landscape

features. The merit of population modeling has long been recognized and has resulted in ongoing development of various types of models for assessing environmental risks of chemicals. However, the hazard-based regulatory framework for the assessment of endocrine-disrupting properties of chemicals recently implemented in Europe has challenged the classical conceptual approach of population modeling, which consists in linking environmental exposure to population-level responses. Given a hazard assessment context where exposure cannot be taken into account, we explored practical options for modelling such a scenario using fish population models. We imposed three effect durations (10-year, 3 months summer, or winter) for six common endocrine disrupting chemical (EDC)-sensitive endpoints (fecundity, fertilization rate, sex ratio: male and female skew, courtship and nesting behavior) at four magnitudes of effect (10, 20, 50 and 90% reduction) using individual-based population models for three fish species with differing life histories: stickleback (Gasterosteus aculeatus), brown trout (Salmo trutta) and zebrafish (Danio rerio). The strongest and most consistent drivers of decline were reproductive endpoints, especially fecundity and fertilization rate; nesting behavior in stickleback produced no population-level response even at 90% disruption. For all endpoints tested individually, effect magnitudes of 20% did not result in any population-level responses in each of the three species, except in the stickleback, where a 20% reduction in fecundity or fertilization rate led to population declines (in these cases, effect magnitudes of 10% did not result in population-level responses). Once standardized, our "exposure-agnostic, molecule-independent" approach will enhance our understanding of population outcomes within the regulatory hazard-based assessment of EDCs.

5.08.P-Tu133 Refining Ecological Risk Assessment of Thiamethoxam for Chironomus riparius Using Tiered Individual- and Population-Level Modeling

Josef Koch[1], Tido Strauss[1], Natalie Dallmann[1], Jana Gerhard[2], Nika Galic[3] and Maxime Vaugeois[4] (1)gaiac eco assessment GmbH, (2)gaiac Research Institute, (3)Syngenta Crop Protection AG, (4)Syngenta Ltd

Mechanistic effect models can strengthen higher-tier ecological risk assessment by linking laboratory toxicity data to field-relevant population outcomes. For aquatic invertebrates, this requires accounting for temperature-dependent toxicity, realistic time-varying exposure, and density-dependent population processes that can influence recovery. Here, we present a tiered modeling framework to refine risk assessment for the neonicotinoid insecticide thiamethoxam (TMX) in Chironomus riparius, a taxon recognized as highly sensitive to neonicotinoids.

At the individual level, we developed a temperature-dependent Dynamic Energy Budget–toxicokinetic–toxicodynamic (DEB-TKTD) model parameterized with laboratory data across multiple TMX concentrations and temperatures. Using a moving-time-window approach, we simulated complete life cycles under contrasting exposure profiles and quantified effects on survival, growth, emergence timing, and reproduction. Survival to pupation was used as an integrative endpoint capturing both lethal and sublethal effects. Exposure multiplication factors (EMFs) were then derived from worst-case TMX exposure time series based on geographically extensive, temporally resolved surface-water monitoring data.

At the population level, we applied an individual-based model incorporating density-dependent processes, including cannibalism, to evaluate how individual-level effects scale to population responses under field-relevant combinations of larval density, food availability, temperature, and exposure dynamics. This approach allowed us to assess whether density dependence can partly offset direct toxic effects and to compare outcomes across realistic open-water and small pond scenarios.

Overall, the combined DEB-TKTD and population modeling framework provides a mechanistically informed

and ecologically relevant basis for refining TMX risk characterization in aquatic invertebrates. More broadly, this work illustrates how integrating individual- and population-level models can reduce uncertainty and improve confidence in higher-tier ecological risk assessment.

5.08.P-Tu134 Mechanistic DEB-TKTD Modeling of Survival and Growth Effects in Lepidoptera Exposed to Insecticides

Josef Koch[1], Simon Hansul[1], Eric Peterson[2] and Maxime Vaugeois[3] (1)gaiac eco assessment GmbH, (2)Syngenta Crop Protection AG, (3)Syngenta Ltd

Current insecticide risk assessments for endangered Lepidoptera often rely on assessment factors informed by honey bee data, which may not adequately reflect Lepidopteran sensitivity or life-history traits. To address this gap, we are developing mechanistic effect models that combine Dynamic Energy Budget (DEB) theory with toxicokinetic-toxicodynamic (TKTD) approaches to quantify insecticide effects on survival and growth across larval stages.

In the first phase of this work, the painted lady, Vanessa cardui, was used as a model species. A recently proposed DEB model for terrestrial holometabolous insects was refined to capture the species' growth trajectory and stage structure. Laboratory studies under dietary exposure generated clear dose-dependent effects on survival and growth across three larval instars, which were analyzed using the DEB-TKTD approach.

Traditionally, (DEB-)TKTD models have focused mainly on aquatic species, where exposure can be described directly from external water concentrations. For terrestrial organisms, however, uptake kinetics must be reformulated explicitly. To address this challenge, we build on recent advances in terrestrial effect modelling and evaluate its applicability for integrating lethal and sublethal endpoints with diet-based and contact exposure metrics in DEB-TKTD.

Laboratory data showed clear dose-response relationships for both survival and growth, with sensitivity varying by life stage. Size-dependent toxicokinetics alone could not fully explain this pattern, so additional assumptions are being explored. Preliminary modeling suggests that allowing an independent effect-slope parameter for each life stage improves model fit while keeping complexity low. Plausible physiological modes of action are also being evaluated to link damage processes to the observed growth effects.

A key strength of our approach is its ability to integrate sublethal and lethal endpoints, as well as both oral and contact exposure routes, within a single mechanistic framework. Ongoing experiments will further refine the model structure and clarify the basis of stage-specific sensitivity. Overall, this work demonstrates the feasibility and added value of DEB-TKTD modeling for Lepidoptera and provides a strong foundation for future risk assessment applications.

From Risk Characterization to Risk Reduction: Environmental and Human Health Risk Assessment and Mitigation Case Studies

5.09.T-01 Integrating Ecological and Human Health Risk in Cumulative Impact Assessment

William Rish[1] and Stephanie Kennedy[1] (1)ToxStrategies

Risk assessments have traditionally focused on individual stressors and discrete endpoints, yet evidence shows

that cumulative impacts arise from the interaction of chemical, physical, biological, ecological, and social stressors across the total environment. Because these stressors propagate through shared pathways, such as water quality, food webs, and ecosystem services, changes in ecosystem condition directly influence human exposure and susceptibility, and vice versa, highlighting the need to evaluate ecological and human health risks in an integrated manner.
A multidisciplinary review of over 600 studies and regulatory frameworks was conducted, focusing on integration of stressors and risk factors across multiple domains. This work synthesized current approaches to cumulative impact assessment (CIA) to evaluate how diverse evidence streams can be combined to better visualize, characterize, and manage risks from a cumulative perspective. It was found that advances in chemical characterization and modeling have improved assessment of individual contaminants, but integration across stressors, media, and biological endpoints remains limited. Applications appeared to rely on broad indicators that do not capture local exposure dynamics, mixture effects, or causal linkages between ecological factors and human health, or human conditions and ecological health.
Some of the more effective frameworks and applications from the study will be shared that include features that have the potential to advance more robust integration of ecosystem and human factors in risk assessments. Study results will be used to illustrate the need to explicitly link ecological condition and human health outcomes to provide a stronger and more complete scientific basis for assessing and managing cumulative impacts. Research needed to improve integration of ecological and human health risk assessment in the context of cumulative impact assessment will be summarized. SETAC provides an excellent forum to discuss and plan progress toward this goal.

5.09.T-02 Advancing Animal-Free Environmental Safety Assessments: Development and Application of an Integrated Next Generation Risk Assessment (NGRA) Framework

Takahiro Suzuki[1], Bruno Campos[2], Christopher Fassbender[3], Giacomo Grassi[4], Juliet Hodges[2], Stephanie Kennedy[5], Markus Hecker[6], Ryan Heisler[7] and Amelie Ott[8] (1)Kao Corporation, (2)Unilever, (3)PETA Science Consortium International e.V., (4)L'Oreal, (5)ToxStrategies, (6)University of Saskatchewan, (7)International Collaboration on Cosmetics Safety (ICCS), (8)International Collaboration on Cosmetics Safety

Given the increasing global emphasis on holistic, integrated environmental safety assessments, the International Collaboration on Cosmetics Safety (ICCS) has convened a multidisciplinary activity team to develop an environmentally focused, exposure-led, hypothesis-driven Next Generation Risk Assessment (NGRA) framework for cosmetic ingredients. The framework is intended to leverage exposure, including spatially explicit models, New Approach Methodologies (NAMs), mechanistic data, and multiple lines of evidence to improve environmental safety evaluation without reliance on animal testing.

Recognizing the complexity of integrating diverse environmental data streams into a single assessment paradigm, this work will identify opportunities to incorporate ecotoxicological, mechanistic, and exposure-related information into a scientifically robust environmental safety assessment framework that focuses on the protection of the ecosystem rather than the prediction of individual species toxicity. A landscape review of existing environmental and NAM-based assessment frameworks was conducted to identify current approaches, areas of overlap, and key scientific gaps relevant to the development of the framework presented herein.

Through the development of a new NGRA framework and application of case studies, this project aims to

improve understanding of how existing tools can be integrated to support scientifically robust, animal-free environmental safety assessments. This presentation will describe the approach used to develop the draft framework and walk through initial findings from a first case study used to "stress-test" the framework and highlight key scientific and practical challenges encountered during the process.

Disclaimer/Disclosure: This work is funded by the International Collaboration on Cosmetics Safety

5.09.T-03 Beyond the Soil Sink: Integrated Risk Assessment of Chemical Mixtures and Antimicrobial Resistance in Wastewater Residuals

Harmanpreet S Sidhu[1] and Greg Slater[1] (1)McMaster University

The land application of wastewater residuals is becoming vital for circular agriculture but introduces complex contaminant mixtures and antimicrobial resistance determinants (ARDs) into terrestrial ecosystems. Current regulatory frameworks rarely assess the cumulative risks posed by chemical mixtures and proliferation of antimicrobial resistance, nor do they adequately compare how the physical state of the delivery matrix (biosolids vs effluent) influences ecological fate. To address these gaps, we executed a tiered integrated risk assessment utilizing data from a comprehensive, multi-trophic greenhouse study, enabling the evaluation of dynamic environmental scenarios across effluent-irrigated and biosolids-amended treatments. We evaluated exposure pathways relevant to human dietary intake, avian predators of soil invertebrates, and aquatic ecosystems. To assess unattenuated gross ARD exposure to the organisms, we utilized novel metrics: average daily genetic dose (ADGD) and estimated genetic environmental concentration (EECgenetic). While contaminant mass transfer to plants was restricted across both matrices, stringent regulatory thresholds for PFAS still yielded elevated human dietary risk metrics. For predator and aquatic ecosystem pathways, matrix effects diverged between chemical and ARD targets. For chemicals, biosolids drove greater trophic risks (primarily due to PBDEs) and aquatic hazards (due to carbamazepine) compared to effluent. Conversely, for ARDs, this matrix influence was dampened as biological amplification likely overrode physical delivery state. Soil-ingesting invertebrates actively accumulated and amplified ARDs across both matrices to deliver high unattenuated ADGDs ($>10^{10}$ copies kg^{-1} d^{-1}) to secondary predators. Our findings highlight the need to incorporate complex mixture toxicity and ARD proliferation risks into sustainable wastewater residual use policies. Assessing the risk of anthropogenic antimicrobial resistance proliferation is currently precluded by lack of established thresholds and parameters that evaluate real attenuated exposure. To operationalize the gross unattenuated genetic metrics and address the lack of empirical parameters required for assessment of antimicrobial resistance proliferation risk, we propose an adjustable three-equation framework partitioning the initial exposure into in vivo colonization and secondary environmental shedding.

5.09.T-04 Comparing Petroleum Hydrocarbon Assessment Frameworks in the United States and Canada

Theresa Lopez[1] and Kelly Jones[1] (1)Tetra Tech

Petroleum hydrocarbon releases to soil and groundwater present persistent environmental and human-health concerns across North America, yet the methods used to assess these releases vary between jurisdictions. This paper compares the principal approaches used in the United States and Canada for evaluating petroleum

hydrocarbon impacts in soil and groundwater, with emphasis on how regulatory frameworks, analytical methods, and risk-based decision tools shape site characterization and remedial decision-making. The review examines the use of total petroleum hydrocarbon measurements, fraction-based assessment methods, soil vapor and groundwater screening, and multiple lines of evidence for determining exposure potential and contaminant mobility. It also evaluates how U.S. state and federal guidance differs from Canadian provincial and federal practices in addressing petroleum mixtures, weathering, plume behavior, and site-specific risk.
The analysis finds that U.S. approaches tend to be more fragmented but offer flexible state-level implementation, while Canadian approaches are often more standardized in the use of fractionation and tiered risk assessment. Both countries increasingly rely on risk-based frameworks, but they differ in data requirements, contaminant grouping, and the balance between generic criteria and site-specific evaluation. The paper concludes that no single approach is universally superior; rather, the effectiveness of an assessment method depends on site conditions, intended land use, hydrogeologic setting, and regulatory context. A harmonized framework that integrates petroleum fraction chemistry, exposure pathways, and practical decision thresholds could improve consistency, transparency, and defensibility in cross-border environmental assessments.

5.09.T-06 Risk Management as a Mechanism for Ecological and Cultural Reclamation - Sp’akw’us Feather Park

Tracey L'Espérance[1] (1)Stantec Inc.

Located at the confluence of mountains and ocean, Squamish, British Columbia, lies within the traditional territory of the Sḵwx̱wú7mesh Úxwumixw, whose people have stewarded these lands since time immemorial. Starting in the 1960s, a chlor-alkali plant operated on the Oceanfront Peninsula, producing caustic soda, hydrochloric acid, and chlorine for the pulp and paper industry. These historical operations resulted in the release and deposition of mercury contamination. After the plant ceased operations, the province of British Columbia ordered remediation which resulted in the removal of 140,000 tonnes of waste material, implementation of water treatment systems, and established long-term monitoring. Despite these efforts, high-risk groundwater discharge and intertidal sediments remained.
The nature of the conditions is such that risk management informed by risk assessment was the only feasible strategy. Some of the key challenges within this UNESCO Biosphere Region included the tidal marine environment, sediment dynamics from nearby shipping and river deposition, key habitat areas, unregulated parameters, and biotransformation of elemental mercury to biomagnifying methylmercury. Consequently, risk assessment guided decision-making from the earliest stages of site investigation through remedial design, construction planning, implementation, and eventual certified closure. Risk-based solutions were designed and implemented by an interdisciplinary team of toxicologists, chemists, engineers, hydrogeologists, biologists, ethnobotonists, agrologists, and landscape architects.
A crucial component of the remediation strategy was the development of Sp’akw’us Feather Park at the terminus of the Oceanfront Peninsula. The park was created in collaboration with the Squamish Nation, and their culture, knowledge, and teachings are woven throughout the final design. While the park capped and mitigated exposures to contaminated sediments, it also introduced unique exposure pathways through the creation of terrestrial medicinal and traditional-use gardens, traditional aquatic root gardens, and restored aquatic habitat for culturally significant species. Opened in 2024, Sp’akw’us Feather Park demonstrates how risk management can facilitate not only environmental remediation, but also the ecological and cultural

reclamation of a historically contaminated site, enabling the return of community and cultural use to the Squamish waterfront.

From Risk Characterization to Risk Reduction: Environmental and Human Health Risk Assessment and Mitigation Case Studies

5.09.P-Tu286 Environmental Impacts of Silicate Mud in Oil & Gas Surface Hole Drilling

Mazhar Ali Rind[1] and Tabish Latif Abro[1] (1)United Energy Group

Silicate-based drilling fluids are widely used drill different sections of Oil & Gas wells including surface hole to improve borehole stability and minimize shale & Clay-related drilling challenges. However, concerns remain regarding their potential impacts on shallow aquifers, vegetation, and human health, particularly in areas where groundwater is used for drinking and irrigation.

This study investigates the environmental risks associated with the use of sodium silicate mud systems during surface hole drilling operations, focusing on the likelihood of groundwater contamination and subsequent ecological and public health effects. The primary challenge addressed is whether silicate mud, due to its high fluid loss characteristics and chemical composition, can adversely affect water-bearing formations and surrounding communities.

The work evaluates the chemical constituents of the silicate mud system—including potassium chloride (KCl), sodium silicate, and high-pH water phase—and analyzes their pathways of entry into the environment through filtrate invasion into shallow formations. The approach is based on reviewing mud composition, examining contaminant mobility in soil and water systems, and assessing possible impacts of excessive sodium, chloride, potassium, and alkalinity on vegetation and human health.

Findings indicate that chloride concentrations in silicate mud can reach extremely high levels (24,500–38,000 mg/L), which may cause severe salinity stress in plants even after dilution. High sodium concentration and elevated pH may reduce soil permeability, disrupt nutrient uptake, damage soil microbial activity, and degrade long-term soil fertility. In addition, groundwater contamination may contribute to health risks such as hypernatremia, hyperkalemia, hypertension, kidney stress, and electrolyte imbalance in affected populations.

The study concludes that silicate mud use in surface hole drilling poses significant environmental concerns, particularly due to its potential to contaminate shallow freshwater zones. It recommends restricting surface hole drilling fluids to clay-based bentonitic mud systems, reviewing casing design to protect aquifers, and implementing groundwater monitoring programs. These findings support safer drilling practices by emphasizing prevention of groundwater pollution and promoting sustainable environmental management in oil and gas operations.

Disclaimer/Disclosure: This document is for informational and academic purposes only, based on available literature and qualitative assessment. It is not legal, medical, environmental, or engineering advice. Impacts may vary by site conditions. The author accepts no liability; consult experts before action.

5.09.P-Tu287 Unraveling the Mercury Pathway: Sediment Contamination, Food Web Accumulation, and Risk Assessment at a Superfund Site (Lavaca Bay, Texas, USA)

Jessica Dutton[1], Joseph Kuntz[1] and Jordan Daniels[1] (1)Texas State University

The Alcoa Point Comfort Operations Plant (Texas, USA) refined bauxite from 1958 to 2016. In the 1960s and 70s, mercury (Hg) was released into Lavaca Bay via wastewater from a chlor-alkali production plant. The bay next to the facility was closed to the retention of fishes and blue crab (Callinectes sapidus) in 1988 and designated a Superfund site in 1994. Biomonitoring of Hg concentrations in red drum (Sciaenops ocellatus) since 1996 have shown that while concentrations are declining, they are still higher than expected given long-term remediation efforts. This study measured Hg concentrations in muscle tissue of red drum, black drum (Pogonias cromis), spotted seatrout (Cynoscion nebulosus), hardhead catfish (Ariopsis felis), southern flounder (Paralichthys lethostigma), and blue crab caught in the Superfund site and compared the concentrations to conspecifics in other areas of the Matagorda Bay system (western Lavaca Bay, Tres Palacios Bay, Matagorda Bay). Depending on the species, Hg concentrations, on average, were 1.5 to 9.2-times greater in the Superfund site compared to other areas. For all species except spotted seatrout, Hg concentrations decreased with increasing distance from the Superfund site. >40% of red drum, black drum, and hardhead catfish had a Hg concentration exceeding the Texas human health-based standard (0.7 µg/g wet weight) indicating the retention ban needs to remain in effect. To investigate why Hg concentrations were still elevated in fishes and blue crab, 60 sediment cores were collected from the Superfund site and the Hg concentration measured in 2 cm sectioned intervals to determine how Hg concentration varied with depth and at what depths the Hg concentration peaked. Most cores had elevated Hg concentrations and 21.7% of cores (n = 13) had Hg concentrations exceeding the U.S. Environmental Protection Agency (EPA) open water cleanup goal (0.5 µg/g dry weight) within the first 30 cm depth. The greatest reported Hg concentration was 13.5 µg/g dry weight at 8 cm depth. Fishes and blue crab most likely have elevated Hg concentrations due to consuming contaminated prey that are linked to the benthic food web. Areas of the Superfund site that have sediment Hg concentrations exceeding the open water clean-up goal should be dredged to remove the contaminated sediment. To assist remediation efforts, further investigation is needed to determine why Hg concentrations are still high in surface sediment, especially 0-10 cm depth.

5.09.P-Tu288 Ecological Risk Assessment of PFAS in Kettle Ponds and Surrounding Soils

Joy Mcgrath[1], William Schew[1], Stephanie Maggio[1], John Paquin[2], Jennifer McKechnie[2], David Leone[2] and Paul Ruszala[3] (1)GHD, (2)GZA, (3)Barnstable County, MA

Historical use of aqueous film forming foam (AFFF) at fire training facilities has resulted in the release of per- and polyfluoroalkyl substances (PFAS) into surrounding environments, raising concerns about potential risks to ecological receptors. PFAS are a class of synthetic compounds known for their persistence and ability to bioaccumulate, making them contaminants of emerging concern in both terrestrial and aquatic ecosystems. This case study presents an ecological risk assessment for a former fire training facility and surrounding environmental area located in Cape Cod, Massachusetts. This is a region characterized by kettle ponds, which are groundwater-fed depressions formed by glacial activity that lack surface inlets and outlets. The site consists primarily of forested land interspersed with small ponds and wetlands and provides habitat for a variety of terrestrial and aquatic ecological receptors. A Screening Level Ecological Risk Assessment (SLERA) was conducted to evaluate the potential for unacceptable risks posed to ecological receptors from PFAS present in

environmental media in terrestrial and aquatic environments. Sampling of PFAS was conducted in soil, sediment, surface water, and biota. Biota sampling included fish and aerial insects and were used to develop receptor-specific food chain exposure models to estimate potential effects of bioaccumulation. Site-specific measurements reduced the uncertainty in the risk evaluation. The risk assessment indicated minimal risks to ecological receptors from exposure to residual PFAS at the Site. Based on these results, additional investigation or remediation at the Site is not anticipated to be required for further risk reduction.

5.09.P-Tu289 Vapor Intrusion Modeling in a Site-Specific Risk Assessment: Case Study on the Implications of Model Parameterization and Approach

Yvonne Rericha[1], Nadia Podpora[1], Tamara House-Knight[1] and Francis C. Ramacciotti[1] (1)GHD

Vapor intrusion (VI), the migration of volatile chemical vapors from subsurface sources, such as groundwater, into enclosed buildings, is an important exposure pathway to consider in human health risk assessments for sites impacted by volatile organic compounds (VOCs). A VI risk assessment requires three co-occurring elements to establish a current or potential future exposure: a vapor source, a subsurface migration route, and a building/receptor. For a comprehensive evaluation, it is often important to measure and model VOC concentrations in groundwater, soil vapor, sub-slab vapor, and/or indoor air. A widely used VI model to estimate concentrations in indoor air to which receptors may be exposed is the California Department of Toxic Substances Control's (DTSC) version of the Johnson and Ettinger (J&E) model. The model is based on the U.S. EPA's J&E model and enables greater flexibility for model inputs, including selecting from one of two capillary fringe models, i.e., U.S. EPA's box model or the van Genuchten moisture retention profile model. Both models estimate soil moisture, which limits vapor movement within the soil column; however, the results can be quite different. When using VI models to assess a site, site-specific model parameterization is vital to reach appropriate conclusions regarding the need for VI mitigation. Parameters such as subsurface geology vary between sites and can even vary within a single site boundary. Leveraging a case study for a portion of a geologically complex site that has legacy concentrations of trichloroethene (TCE) in groundwater, this presentation compares estimated exposure (i.e., risk) using various VI modeling decisions. Comparisons demonstrate how conclusions would change when generalizing the entire site versus separately evaluating geologically delineated areas within the site. Further, results using U.S. EPA's capillary fringe model are compared to the van Genuchten model. A multiple lines of evidence approach using available site data is used to validate the model performance. The risk assessment approach and the implications of differing regulatory and technical guidance for VI risk assessments, especially in light of the regulatory pushes to use predominantly generic assumptions, will be discussed.

5.09.P-Tu290 Modelled Steady-State Concentrations of Contaminants of Concern Within an Underground Parking Garage To Demonstrate Sufficient Risk Reduction for the Protection of Human Health in an Urban Environment

Nicole Knezevich[1] and Ian Collins[1] (1)GHD

In Canada, there are approximately 30,000 brownfield sites, which may be redeveloped to encourage densification and combat urban sprawl. These sites typically require remediation and/or a risk assessment in conjunction with a risk management plan to effectively reduce unacceptable risks to human health and

ecological receptors. An underground parking garage is a commonly used risk management measure (RMM) in urban settings to address vapour intrusion concerns as it is easily incorporated into redevelopment concepts. However, recently, regulators have requested modelling to confirm that the use of a parking garage RMM provides adequate risk reduction to future human receptors, particularly for contaminants of concern (COCs) with developmental effects. To demonstrate that the parking garage RMM provides adequate protection to future receptors, the predicted steady-state concentrations of COCs within an underground parage garage were modelled, based on conservative assumptions. The predicted steady-state concentrations of the COCs within the underground parking garage were compared to provincially regulated Health Based Indoor Air Criteria (HBIACs), to confirm the underground parking garage provided adequate protection for future site receptors. This model was applied for two brownfield urban developments in Toronto, Ontario where the redevelopment concept plans included multi-level underground parking garages. Groundwater COCs identified at these sites included chlorinated volatile organic compounds and petroleum hydrocarbons, respectively. The application of this model demonstrated that the predicted steady-state concentrations of the groundwater COCs in the underground parking garages were less than the HBIACs. Therefore, in these two case studies, the need for additional RMMs in conjunction with the parking garage, such as a costly vapour mitigation system, was ruled out as the underground parking garage alone was shown to provide a sufficient level protection for the vapour intrusion exposure pathway. This model may be applied for other urban brownfield redevelopments.

5.09.P-Tu291 Occupational Exposure to Endotoxins and VOCs in Indoor Cannabis Cultivation: A Systematic Review and Comparison With Non-Cannabis Greenhouses

Ryan Potts[1] and Oluwabunmi Dada[1] (1)Murray State University

Background: Indoor cannabis cultivation facilities (ICCFs) represent a rapidly expanding occupational environment in North America where workers may be exposed to endotoxins, volatile organic compounds (VOCs), terpenes, cannabis dust, and bioaerosols. Despite increasing concerns regarding respiratory health risks, occupational exposure data remain limited.
Objective: To synthesize evidence on occupational endotoxin and VOC exposures and associated respiratory health outcomes in ICCFs and compare findings with those reported in non-cannabis indoor cultivation environments.
Methods: A systematic review was conducted in accordance with PRISMA 2020 guidelines. Academic Search Ultimate, PubMed, and Web of Science were searched for studies published between January 1, 2016, and February 26, 2026. Eligible studies evaluated occupational inhalation exposures and respiratory health outcomes in indoor agricultural or horticultural settings. Data extracted included exposure measurements, respiratory outcomes, and study characteristics.
Results: Of 272 records identified, 13 studies met the inclusion criteria. Five studies evaluated endotoxin exposure, with only one conducted in an ICCF. In non-cannabis facilities, personal endotoxin concentrations averaged up to 392 EU/m³ and peak levels exceeded 3,700 EU/m³, surpassing the Dutch Expert Committee on Occupational Safety reference value of 90 EU/m³. Two ICCF studies measured VOCs, including diacetyl, 2,3-pentanedione, and terpenes. While diacetyl and 2,3-pentanedione concentrations remained below recommended exposure limits, terpene concentrations were highest during trimming and cultivation activities. Reported respiratory outcomes included asthma, cough, chest tightness, nasal congestion, reduced pulmonary function, and increased fractional exhaled nitric oxide. Harvesting, pruning, and trimming tasks were consistently associated with elevated exposure levels.

Conclusions: Evidence on occupational respiratory exposures in ICCFs remains limited. Available studies suggest that cultivation and processing tasks may increase exposure to airborne contaminants associated with adverse respiratory outcomes. Longitudinal studies integrating exposure assessment and health monitoring are needed to better characterize exposure-response relationships and support occupational health protections.

5.09.P-Tu292 Identifying Risk-Driving Chemicals in Human Exposure Mixtures Through Population Biomonitoring and Experimental Models

Yunchul Ihn[1], Gokce AYAZ Nur[1], Eunhye Kim[1], Yujin Park[1], Naeun Kim[1], Jongchun Ahn[1], Sooyoung Kim[1] and Kyungho Choi[1] (1)Seoul National University

Human exposure to synthetic chemicals occurs as complex mixtures, yet identifying the components that disproportionately drive mixture toxicity remains a major challenge for risk assessment. Here, we integrated national biomonitoring data with experimental toxicology to reconstruct population-representative chemical mixtures and evaluate whether different prioritization frameworks could identify biologically relevant risk-driving chemicals. Mixtures were reconstructed from urinary biomonitoring data from the Korean National Environmental Health Survey (KoNEHS) and the U.S. National Health and Nutrition Examination Survey (NHANES), focusing on commonly detected short half-life endocrine-disrupting chemicals. Candidate risk drivers were prioritized using three approaches: hazard-based weighting using hazard quotient, co-exposure-based prioritization using association rule mining, and an integrative multidomain approach using ToxPi, which incorporated bioactivity, physicochemical properties, and internal exposure metrics. Full mixtures and reduced mixtures excluding prioritized chemicals were then tested in H295R steroidogenic cells and embryo-larval zebrafish models.

Both KoNEHS- and NHANES-derived full mixtures induced measurable biological responses across experimental systems. In H295R cells, both mixtures increased estradiol levels, E2/T ratio, and up-regulated steroidogenic genes. In zebrafish larvae, the NHANES-derived mixture disrupted thyroid hormone homeostasis, whereas the KoNEHS-derived mixture increased proteinuria. Both mixtures altered neurobehavioral endpoints during dark-phase locomotor responses. Prioritization methods identified distinct and largely non-overlapping sets of candidate drivers. Across endocrine, renal, and neurobehavioral endpoints, reduced mixtures excluding chemicals prioritized by the integrative multidomain approach produced the most consistent attenuation of mixture-induced responses, whereas hazard-based and co-exposure-based exclusions showed more limited attenuation.

These findings suggest that biological activity within complex population-representative mixtures is not uniformly distributed but may be disproportionately driven by a limited subset of chemicals. By linking biomonitoring-derived exposure profiles, computational prioritization, and experimental validation, this framework provides strategy for identifying candidate risk drivers and improving the biological relevance of mixture risk assessment.

Disclaimer/Disclosure: This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (RS-2025-00513967).

5.09.P-Tu293 A Multiple Lines of Evidence Approach to AFFF-Impacted Soil Cleanup

Nadia Podpora[1], Francis Ramacciotti[1], Zhiyong Xia[1] and Mauricio Barrera[1] (1)GHD

Aqueous film forming foam (AFFF) releases associated with emergency response to fuel fires pose significant challenges for soil cleanup due to the complex mixture of per and polyfluoroalkyl substances (PFAS), the variable makeup of AFFF, and the environmental persistence or and environmental transformation of PFAS in AFFF. This presentation describes a multiple-lines-of-evidence approach used to investigate and remediate AFFF impacted soils following an explosion fire.

Remedial decision making was guided by an integrated, site specific framework that combined observational evidence, analytical data, and risk based evaluation. Cleanup activities focused on excavation of visually impacted soils, supported by measuring and evaluating PFAS concentrations relative to site specific background levels and soil screening levels developed using applicable exposure assumptions and toxicity criteria. Visual indicators of impact, including soil staining, aerial imagery taken during the response documenting the extent and flow and drainage of foam and water, presence of residual foam in the soil, and land disturbance associated with the fire and fire suppression activities were evaluated. These conceptual site model observations were used in combination with laboratory results to define the nature and extent of AFFF related impacts. The evaluation also considered PFAS degradation products and precursor compounds to account for transformation processes and the potential for future PFAS generation in residual soils in this area where groundwater is used as an off-site drinking water source.

This multiple lines of evidence framework supported holistic decision making, accelerated the cleanup process, reduced uncertainty associated with PFAS occurrence, and improved transparency in cleanup. This presentation will discuss how qualitative and quantitative lines of evidence can be integrated to conduct risk based remediation strategies at AFFF impacted sites.

5.09.P-Tu294 Enhancing per and Polyfluoroalkyl Substances (PFAS) Sequestration and Elimination in Livestock Through Dietary Binders

Kailey Kuhlman[1], Juan Romero[1], Glenda Pereira[2], Kizito Nishimwe[1], Ana Jimenez[1], Jair Rodriguez[1], Marco Guevara[1], Jonalyn Sandro[1] and Yun Jiang[3] (1)University of Maine, (2)University of Maine Cooperative Extension, (3)University of Wisconsin-Madison

Due to the known widespread contamination and health effects of per and polyfluoroalkyl substances (PFAS), we stress the importance of minimizing contamination in livestock therefore addressing the main human contamination route of dietary intake. We aim to optimize the efficiency of a PFAS feed binder in order to mitigate the effects of PFAS on livestock ruminants and lower the levels of PFAS in food products sourced from these animals.

Using PFOS-contaminated (Perfluorooctanesulfonic acid) alfalfa under simulated ruminal conditions, preliminary studies tested a variety of potential PFOS binders for binding affinity and indigestibility. The binders tested include a cationic feed binder, cholestyramine, a modified cationic polymer, a natural feed byproduct, a modified polysaccharide, a modified clay binder, and a dioctahedral phyllosilicate clay binder. Of these, cholestyramine bound the greatest amount of PFOS (89.6%) with the cationic polymer (31%) and natural

feed byproduct (26.8%) binding the next greatest amounts of PFOS. The tested adsorption had an SEM of 7.56 and P<0.01. Several binders, including the natural feed byproduct, showed the capacity to sequester PFOS without affecting microbial fermentation and gas production.

Given the price point of cholestyramine, natural feed byproduct binders will be focused on as a more accessible solution for farmers. Various feed byproducts (byproduct1, byproduct2, byproduct3, and byproduct4) will be compared in terms of binding affinity. The byproduct binder with the greatest affinity will be tested under various chemical conditions(none, some, and total), pressure(psi 0 vs psi 15), and temperature (25 C, 70C, and 150 C). The contaminated alfalfa and each variation of the feed byproduct binder are added to 100 mL of rumen media in Ankom bottles, shaken at 60 rpm for 48 hrs at 39°C. After the incubation, the ruminal supernatant and ruminal pellet are analyzed using the modified EPA 537 method. A randomized complete block design (n=5) will be used to analyze the data through SAS version 9.4. The respective P values will be compared and significant differences determined at $P \leq 0.05$. We hypothesize that the feed byproduct binder with the least amount of digestibility in the rumen and the greatest concentrated level of known proteins that bind to PFAS, will be the most successful as a feed binder candidate.

Disclaimer/Disclosure: EPA under Umaine Extension Grant 01PFAS_Romero2025

5.09.P-Tu295 Beyond Total Chromium: How Speciation Changed Ecological Risk and Remediation

Matthew LeFauve[1], Bart Hoskins[2], Richard Fisher[2], Geoffrey Schwartz[1], Maryann Sapanara[1] and David Leone[1] (1)GZAGeoEnvironmental, (2)US Environmental Protection Agency

A former chromium-plating facility was evaluated through an Ecological Risk Assessment and remedial evaluation to assess and address widespread chromium exposure impacts in groundwater, surface water, sediment, and soils. The Initial Screening Level Ecological Risk Assessment process based primarily on total chromium suggested significant ecological risk in many receptors across several complete exposure pathways. The total chromium concentrations in sediment and soil indicated the potential for widespread ecological impairment, with potential to support a large-scale remedial excavation of media. However, a Baseline Ecological Risk Assessment (BERA) revealed that ecological risk was not uniformly associated with total chromium concentrations. The BERA considered additional characteristics of the exposure ecosystem including chromium species, porewater chemistry, sediment bioavailability, and toxicity testing to modify direct contact and food-web modeling. Those data suggest that risk was instead primarily driven by dissolved and mobile hexavalent chromium (Cr(VI) in discharged groundwater and surface water. In contrast, sediments and soil concentrations containing elevated total chromium concentrations exhibited limited toxicity and low apparent bioavailability with porewater analyses indicating that much of the total chromium present was in a less bioavailable form, including trivalent chromium (Cr(III)). As such, the BERA process refined and reduced the risk from exposure for many receptors and altered the final remedy selection at the site. Instead of widespread media excavation, targeted source removal, in situ treatment, and permeable reactive barriers were selected to chemically reduce the chromium and reduce bioavailability in the ecosystem. This case study demonstrates how incorporating metal speciation and bioavailability, and multiple rounds of toxicity testing into ecological risk assessments can significantly improve risk characterization and support more technically defensible remedial decisions.

Disclaimer/Disclosure: The views expressed in this abstract and presentation are those of the author(s) and do not necessarily represent the views or the policies of the U.S. Environmental Protection Agency.

5.09.P-Tu296 What Should a Long-Term Monitoring Program for Flowing Waters of the Columbia River Basin Look Like

Patrick Moran[1] (1)U.S. Geological Survey (USGS)

Following 2016 updates to the Clean Water Act, US EPA expanded support for coordinated toxics monitoring in the Columbia River Basin by actively supporting a Toxics Monitoring Sub-Group and establishing a regional funding assistance program. This support renewed several long-standing efforts by US EPA Region 10 and cities, counties, states, Tribes and federal agencies in the region related to toxic chemical monitoring and reduction actions. Early partnerships between the USGS and the Yakama Nation envisioned a 600-mile, 50-year 'monitoring framework' focused on filling a data gap from the region's large rivers and providing a regular source of information to assess risks to human fish-consumers and large river biota. Through 18 listening sessions, two in-person meetings, and contributions from numerous participants, the 'Framework' evolved into a 'Toxics Monitoring Strategy' for the region and a Draft Monitoring Plan. Key points of consensus across the listening sessions and meetings included, but were not limited to: a) risk to human health and aquatic biota was equally important, b) prioritizing chemicals for investment by risk to humans and aquatic biota was justified, c) participants emphasized the importance of Tribal fisheries and related resource concerns, d) the large rivers of the region were both a jurisdictional and practical challenge to sample, e) sensitivity- a desire to document changes (both improvements and degradations) where land-use activities are likely to change water quality, f) trends- consistent endpoints and methods and committed leadership to assess trends over time utilizing both historical and future data, and g) partnership- a clear desire to conduct the monitoring in partnership with interested parties of the region in a way that is both more inclusive and more efficient than traditionally funded. These conversations, which continue, suggest a three-part monitoring design where efforts are focused on: 1) anadromous salmonids, most of which are threatened or endangered, yet sustain high human consumption amounts, 2) methods and SOPs for consistent (spatial and temporal) large river characterization(s), and 3) consistent spatial comparison and localized information for the hundreds of smaller watersheds of the Region. This presentation will summarize the draft Strategy and Monitoring Plan.

5.09.P-Tu297 PM2.5 Resuspension and Antimicrobial Activity of Mattress Materials

Ji Soo Kim[1], Hanbee Baek[1], Hyeree Kim[1] and Kiyoung Lee[2] (1)Department of Environmental Health Sciences, Graduate School of Public Health, Seoul National University, Seoul, Republic of Korea, (2)Department of Environmental Health Sciences, Graduate School of Public Health, Seoul National University

Sleep occupies roughly one-third of adult daily life, and mattresses are used continuously for years, accumulating dust, skin cells, and microorganisms over time. Physical disturbance during sleep can release these contaminants into the breathing zone as resuspended particles or microbial aerosols.
This study evaluated PM2.5 resuspension across three structurally distinct mattress materials—airweb (polyethylene open-network), memory foam (viscoelastic polyurethane), and latex (natural rubber foam)—and antimicrobial activity of memory foam and latex. Resuspension was quantified in a sealed chamber following controlled mechanical impact. Dust loading was varied at 1, 2, and 4 g with aging fixed at one day. Aging duration was varied at 0, 1, and 5 days with loading fixed at 1 g. Peak PM2.5 concentration was measured 30

cm above the surface with three replicates per condition. Antimicrobial activity against S. aureus, K. pneumoniae, E. coli, and C. albicans was assessed under four conditions per ISO 20743:2021, with results expressed as activity values (A) reflecting the log-difference in viable cell counts between control and test specimens after incubation.
Airweb showed consistently low resuspension regardless of dust loading or aging duration. Resuspension on memory foam was sensitive to dust loading, while resuspension on latex increased with aging duration. Latex achieved A ≥ 3.0 (≥99.9% microbial reduction) across all organisms and conditions, including those supplemented with artificial body fluids. Memory foam showed limited antimicrobial capacity in most cases. Airweb presents the lowest resuspension risk among the three materials, while memory foam and latex each show condition-specific increases. Latex demonstrated clear advantages for microbial control while memory foam showed negligible antimicrobial capacity. These findings provide material-specific data to support risk characterization and mitigation strategies in residential sleep environments.

Disclaimer/Disclosure: This study was supported by the Chemical Safety Management Specialized Graduate School Program funded by the Ministry of Climate, Energy and Environment of the Republic of Korea and administered by the Korea Environment Conservation Agency (KECA) in 2026.

5.09.P-Tu298 Allium fistulosum as a Bioindicator for Identifying Vulnerable Groundwater Areas in Yucatán, Mexico

Maria Concepción Gómez Maldonado[1], Gabriela Rodriguez Fuentes[2] and Elsa Norena-Barroso[2]
(1)Universidad Nacional Autónoma de México (UNAM), (2)National Autonomous University of Mexico (UNAM)

The karstic nature of the Yucatán Peninsula increases groundwater vulnerability to contamination due to rapid infiltration. Groundwater is the primary source of water supply for numerous communities in Yucatán, Mexico. Several studies have reported the presence of contaminants in different municipalities across the state; however, conventional chemical analyses do not always allow the toxicological risk associated with complex mixtures of contaminants present in groundwater to be determined. This study evaluated the potential of Allium fistulosum as a bioindicator of cytotoxicity and genotoxicity in groundwater from 24 domestic wells located in Hunucmá, Sisal, Mérida, and Tizimín during the dry and rainy seasons. For this purpose, the MAT index (a variation of the mitotic index), the frequency of nuclear abnormalities, and root growth were assessed as biomarkers of contamination. In parallel, 59 contaminants, including nutrients, metals, volatile organic compounds, and pesticides, were quantified. Results revealed significant seasonal, spatial, and quantitative differences among sites. Cytotoxicity analyses showed significant differences from the control in 11 wells during the dry season and six during the rainy season, while no statistically significant differences were observed in terms of genotoxic effects. Correlation analyses identified benzene, xylenes, nitrate, chlorpyrifos, and several metals as the contaminants most strongly associated with A. fistulosum biomarkers, including mitotic activity, nuclear abnormalities, and root growth inhibition, underscoring the ecological and public health risks posed by groundwater contamination in the region. Several contaminants exceeded national and international regulatory thresholds, including ammoniacal nitrogen, lead, and chlorpyrifos, particularly in wells from Sisal and Mérida. These findings support the use of A. fistulosum as a sensitive and cost-effective biomonitoring tool to complement groundwater quality monitoring programs in karst regions and facilitate the early detection of potential toxicological risks in socially vulnerable communities.

Disclaimer/Disclosure: Acknowledgements
To Posgrado en Ciencias del Mar y Limnología, UNAM for supporting the research that led to the completion of the doctoral degree, CONAHCYT for being awarded a scholarship to pursue doctoral studies and grants UNAM-DGAPA-PAPIIT IN203321 and IN211724 awarded to GRF and ENB.

From Risk Characterization to Risk Reduction: Environmental and Human Health Risk Assessment and Mitigation Case Studies

5.09.V-01 Ultra-Trace Tracking in Lake Titicaca - Peru: ICP-MS Revealing the Toxicological Risk of Heavy Metal Bioaccumulation in Fish and Its Impact on Human Health

Alberto Choquecota Riva[1] and Lisveth Flores del Pino[2] (1)Doctorado en Ingeniería y Ciencias Ambientales, Escuela de Post Grado, Universidad Nacional Agraria La Molina (UNALM), Lima, Perú. Facultad de Ingeniería Agrícola, Universidad Nacional del Altiplano (UNA), Puno, Perú., (2)Centro de Investigación en Química, Toxicología y Biotecnología Ambiental, Departamento de Química, Facultad de Ciencias, Universidad Nacional Agraria La Molina, 15024, Lima, Perú.

This study comprehensively assesses the potential toxicological risk to human health derived from heavy metal bioaccumulation in four commercially and ecologically crucial fish species (Oncorhynchus mykiss, Odontesthes bonariensis, Orestias spp., and Trichomycterus spp.) collected across the Lake Titicaca basin, Peru. These lacustrine resources constitute the primary dietary protein source for local indigenous populations such as 'Los Urus', a community globally renowned for its ancestral, experiential, and cultural tourism. Using advanced Inductively Coupled Plasma Mass Spectrometry (ICP-MS), toxic and essential ultra-trace metal concentrations were quantified in paired muscle and liver tissue samples during the dry season. Analytical results revealed a sharp hepatic tissue tropism, with arsenic, copper, and zinc concentrations being substantially higher in the liver than in the edible muscle tissue. Conversely, mercury exhibited a homogeneous distribution pattern with an evident size-dependent bioamplification process, reaching a critical peak value of 0.820 mg/kg in the skeletal muscle of larger trout, which remarkably exceeds the maximum food safety thresholds established by international sanitary organizations. Lead concentrations remained predominantly below the limit of quantification (<0.02 mg/kg). Health risk index calculations demonstrated that regular consumption of muscle portions poses a latent toxicological hazard for these vulnerable indigenous communities due to chronic mercury and arsenic exposure. Consequently, ultra-trace contamination in these fisheries urgently demands continuous environmental monitoring and specific public policies aimed at safeguarding regional food security and protecting ancestral socio-ecological heritages.
Keywords: Bioaccumulation, Heavy Metals, Indigenous Communities, ICP-MS, Lake Titicaca, Los Urus.

5.09.V-01 Certified but Contaminated: The PFAS Governance Gap in Food Sustainability Standards

Yan Yan[1], Siyuan Jing[2], Xinxin Zhang[3], Siyan Zeng[3], Qianqian Liu[3], Yinjuan Chen[4], Cuili Wang[4], Xiangyu Liu[5], Thomas Wanger[6], Yanyan Zhang[7] and Weicheng Cui[8] (1)Key Laboratory of Coastal Environment and Resources of Zhejiang Province, School of Engineering, Westlake University, Hangzhou, Zhejiang, China; College of Environmental and Resource Sciences, Zhejiang University, Hangzhou, Zhejiang, China.,

(2)Shanghai Key Laboratory of Atmospheric Particle Pollution and Prevention (LAP3), National Observations and Research Station for Wetland Ecosystems of the Yangtze Estuary, Department of Environmental Science and Engineering, Fudan University, Shanghai, 200438, China., (3)College of Environmental and Resource Sciences, Zhejiang University, Hangzhou, Zhejiang 310058, China; Key Laboratory of Coastal Environment and Resources of Zhejiang Province, School of Engineering, Westlake University, Hangzhou, Zhejiang 310030, China, (4)Zhejiang Key Laboratory of Precise Synthesis of Functional Molecules, Instrumentation and Service Center for Molecular Sciences, Westlake University, Hangzhou, Zhejiang 310030, P. R. China., (5)Key Laboratory of Coastal Environment and Resources of Zhejiang Province, School of Engineering, Westlake University, Hangzhou 310030, China, (6)Production Technology & Diversified Cropping Systems Group, Department of Plant Production, AgroScope, Nyon, Switzerland & Academy of Global Food Economics and Policy, China Agricultural University, China, (7)Research Center for Industries of the Future, Westlake University, Hangzhou 310030, China; Key Laboratory of Coastal Environment and Resources of Zhejiang Province, School of Engineering, Westlake University, Hangzhou 310030, China; Institute of Advanced Technology, Westlake Institute for Advanced Study, Hangzhou 310030, China, (8)Zhejiang Engineering Research Center of Micro/Nano-Photonic/Electronic System Integration, Hangzhou, Zhejiang 310030, China; Department of Electronic and Information Engineering, School of Engineering, Westlake University, Hangzhou, Zhejiang 310030, China.

Ensuring food safety is the uncompromising baseline for sustainable food systems. Public sustainability standards guarantee conventional chemical safety, yet their efficacy against unregulated emerging contaminants like per- and polyfluoroalkyl substances (PFAS) remains empirically untested. As PFAS are highly toxic for the environment and human health, this regulatory blind spot may mislead consumer choices and undermine global food safety governance. Here, we leverage a unique natural experiment in China to assess dietary PFAS risks. Specifically, we quantified 30 targeted PFAS in Japonica rice across public certification tiers (uncertified, Green, Organic) and private retailer reinforcement strategies, comparing industrialized hotspots with ecological agricultural zones. For exposure assessment, we developed age-stratified probabilistic Monte Carlo simulations.

Our analysis reveals that novel PFAS dominate the contamination profiles (93.5% of total mass). Counterintuitively, Green-certified rice exhibits significantly elevated PFAS levels, peaking at 50.4 times the lowest-burden category. This paradox is driven by the unintended biogeochemical trade-offs of ecological substitution practices in specific regions. When translating these profiles into health risks, a profound mismatch emerges. Because novel PFAS drive the risk, applying the widely adopted European Food Safety Authority (EFSA) Σ4PFAS baseline yields a 0% exceedance probability. However, utilizing endpoint-specific relative potency factor (RPF) frameworks reveals that endocrine-disruption risks, particularly for post-weaning toddlers, surge to 99.8%.

To resolve this critical risk-governance disconnect, our study develops a risk transition matrix. This framework validates Organic and retailer-reinforced categories for effectively flattening extreme exposure spikes, while simultaneously identifying cost-effective dietary substitutions under financial constraints. Ultimately, these results demonstrate an urgent need to integrate emerging contaminants into established agricultural standard frameworks to protect vulnerable populations.

Disclaimer/Disclosure: The scientific research project of Westlake University, grant number WU2025A006.

Global Trends Toward Environmental Risk Assessment for Pesticide Registration

5.11.P-Tu162 Alternative Approach for Demonstrating Toxicity of Plant Protection Product Degradates

Twyla Blickley[1], John Marton[1] and Adekunle Adesanya[1] (1)Corteva Agriscience

Regulatory agencies use hazard studies to assess the toxicity and potential risk of pesticides and their degradates (metabolites). For example, the European Union may require major metabolites (formed at ≥10%) in surface water, sediment, and/or soil in environmental fate studies to undergo testing in three to four aquatic species if it is possible the toxicophore is present. This project explores alternatives (biological screens, targeted testing) to the traditional suite of hazard studies to demonstrate that a metabolite has lost the pesticidal toxicophore and is less toxic than parent.

Tiapyrachlor, major soil metabolites X12667539 and X12778675, and major water metabolites X12688711 and X12091194 were assessed for acute toxicity to whitefly nymphs (Bemisia tabaci) exposed via direct contact. While biological screens usually determine pesticidal control (%), the study design was modified to determine the LC50. First instar nymphs were hand sprayed on 3-week-old cotton plants with control or treatment solutions and then held in a controlled environmental chamber. Mortality was recorded when the control successfully developed into 4th instar nymphs. X12688711 was shown to have poor activity with no dose-response in the rangefinder and was discontinued for further testing. Tiapyrachlor, X12091194, X12778675, and X12667539 underwent further testing to estimate LC50 values.

A suite of terrestrial and aquatic organism hazard studies was conducted according to GLP with OECD and/or OCSPP guidelines for tiapyrachlor. The lowest short-term aquatic endpoint was oyster growth inhibition (IC50 = 22.4 mg a.i./L), whereas Daphnia magna had the lowest chronic endpoint. In a stepwise metabolite-testing approach, oyster growth inhibition tests were conducted for all four major environmental metabolites, including soil metabolites that can potentially runoff to surface waters. In the three soil organism reproduction tests with tiapyrachlor, springtail had the lowest NOEC (23.8 mg a.i./kg soil dry weight); therefore, springtail reproduction tests were conducted for the two soil metabolites. Results from these hazard studies were compared to findings from the whitefly insecticidal screen to assess whether each pesticide metabolite was comparable, more, or less toxic than the parent molecule. The studies presented demonstrate that data from biological screens can complement regulatory studies in regulatory decision-making.

5.11.P-Tu163 Development of a Quantitative Forest and Vegetative Buffer Mitigation Tool for Brazilian Pesticide Exposure Scenarios for Aquatic Organisms

Rafael Muñoz-Carpena[1], Romulo Scorza Junior[2], John Howe[1] and Patrick Havens[3] (1)University of Florida, (2)Brazilian Agricultural Research Corporation (Embrapa), (3)Corteva Agriscience UK Limited.

Brazil's 2023 Pesticide Law mandates comprehensive environmental risk assessments, prompting the adoption of a tiered assessment framework. Recently, the Brazilian authority for pesticide registration (IBAMA) mandated that US EPA Pesticide Water Calculator (PWC) will be used for aquatic exposure assessment. However, there is a lack of user-friendly tools to quantify agricultural mitigation practices under Brazilian exposure scenarios and legal frameworks. This project addresses this gap by developing a public-domain, user-

friendly software tool (BR-VFS4PWC) to quantitatively assess pesticide mitigation by vegetative buffers, ensuring alignment with Brazil's specific environmental conditions and the Native Vegetation Protection Law (2012) (the "Brazilian Forest Code"). The purpose of the 2012 law is two-fold: 1) to ensure the conservation and protection of native vegetation and natural resources (i.e., biodiversity and water); and 2) to harmonize environmental conservation with economic land use. The legislation mandates the conservation of native vegetation on private land in two categories classified as Permanent Preservation Areas (APP) and Legal Reserve. While riparian forest buffers are widely accepted in Brazil for forest conservation and for mitigating the effects of agriculture on aquatic ecosystems, recent studies indicate that the 2012 law's provisions may provide insufficient protection, particularly for smaller streams and properties. While the debate centers on the width of forest buffers needed for ecological conservation and water protection, other forms of vegetation, such as grass buffers (VFS), have been shown to be effective at controlling runoff water and sediment phases and, ultimately, pesticides that are sorbed to sediment or in solution. Consistent with USDA recommendations in the United States, a three-zone buffer (grass, forest transition, and native forest) from the field edge to the water's edge could be adopted to enhance the effectiveness of forest buffers for pesticide mitigation in Brazil, with the grass VFS counted toward the total APP requirements. VFS4PWC, a tool that models reductions in peak ecological concentration of pesticides from baseline PWC scenarios when VFS are included with VFSMOD, was modified into BR-VFS4PWC, with the development of parameterizations of typical Brazilian forest and grass vegetation using surface roughness and stem spacing metrics, as well as IBAMA's crop specific aquatic exposure scenarios.

Disclaimer/Disclosure: Funding Source: Corteva Agriscience

5.11.P-Tu164 Adapting the FOCUS VFS for Mitigations in the Risk Assessment of an Insecticide in Brazil

Raghu Vamshi[1], Nathan Brettell[2], Patrick Havens[2], Twyla Blickley[1] and John Marton[2] (1)Corteva Agriscience, (2)Corteva Agriscience UK Limited.

IBAMA is developing pesticide risk assessment methodologies and guidance for Brazil, leveraging EPA's Pesticide in Water Calculator (PWC) model and parameterizing with Brazil-specific crop, soil, and weather scenarios. Vegetative Filter Strips (VFS) are a recognized and quantifiable field mitigation practice used by farmers in many countries to reduce runoff and erosion, and off-field aquatic exposure. The EU FOCUS framework for surface water provides VFS as a conservative mitigation option during exposure modeling, relying on worst-case parameterization of rainfall and runoff events. Based on the VFS width specified, a standard factor is applied to modeled pesticide off-field mass fluxes, resulting in fractional reduction in pesticide mass reaching an adjacent waterbody. A custom VFS tool was developed to implement FOCUS VFS mitigation as a post-process for the PWC model outputs. PWC model in conjunction with the VFS tool, parameterized to represent vegetative strip widths of 10 and 20 meters and applied to the model outputs, was utilized to calculate EECs from applications of an insecticide to several crops in Brazil. Modeled exposure estimates of the insecticide on each crop were evaluated against the lowest hazard endpoint for aquatic organisms.

The results illustrate that, for the simulated insecticide, the extent of additional runoff mitigations depend on the crop, application method, and prevailing agronomic and soil management practices. For sugarcane, acceptable risk to aquatic organisms was demonstrated by combining application patterns, landscape characteristics, and

mitigations already embedded in the scenarios. In citrus, acceptable risk was demonstrated for airblast applications when considering grassed inter-rows, a common management practice in Brazil. For soybean and cotton, Brazilian soil conservation practices such as no till systems and contour farming were sufficient to manage potential aquatic risk. In contrast, corn represented the most sensitive case and warranted a 10-meter VFS in combination with no-till/contour farming in all modeled scenarios to mitigate exposure and achieve acceptable risk. Combining PWC and FOCUS VFS approach enabled practical evaluation of additional mitigation options within the exposure model framework. This work demonstrates that integrating crop specific management practices and external VFS tools into PWC identifies safe uses through targeted, risk based mitigation, rather than uniform restrictions.

5.11.P-Tu165 What('S in) the Shell! Is Shell Deposition an Acute Endpoint?

Alan Jones[1], Sven Ritschar[2], Lennart Weltje[2], Maike Habekost[2] and Tara Catron[1] (1)BASF Agricultural Solutions, (2)BASF Agricultural Solutions Deutschland

Regulatory ecotoxicology increasingly uses endpoints beyond survival to capture species-specific sensitivities. The oyster shell deposition test (OCSPP 850.1025) measures shell growth inhibition as an acute toxicity indicator, yet it is often treated as a survival endpoint in environmental risk assessments. This misclassification overlooks that shell deposition reflects metabolic processes rather than lethality and can lead to overly conservative risk characterizations and disproportionate refinement steps without improving ecological relevance. In the U.S., the regulatory framework for pesticides explicitly recognizes this endpoint as an acute growth measure, underscoring a more proportionate approach compared to other geographies.

Further, there is evidence that oysters are less, or similarly, sensitive compared to standard aquatic species when exposed to pesticides. Therefore, a comparison of growth and survival endpoints of the eastern oyster was conducted and compared to survival endpoints for Daphnia magna. Results indicate that the use of the growth endpoint in environmental risk assessment is not appropriate, particularly for acute risk assessment where survival-based endpoints are more biologically meaningful. While mollusk endpoints add value by broadening species coverage, their interpretation must align with biological meaning to avoid disproportionate outcomes. Clear distinction between growth-based and survival endpoints will ensure scientifically sound decisions and maintain proportionality in risk management.

Pharmaceuticals and Personal Care Products: Innovations in Risk Assessment, Regulation and Science

5.14.T-01 Environmental Risk Assessment of Veterinary Medicines – Experience, Results, and Upcoming Challenges

Silke Hickmann[1], Louis-Marvin Sander[2] and Ebert Ina[1] (1)German Environment Agency (UBA), (2)German Environment Agency

The environmental risk assessment of veterinary medicines following VICH GL 6 and GL 38 has been performed in Europe for two decades now. The guidelines are harmonised under VICH, the International Cooperation on Harmonisation of Technical Requirements for Registration of Veterinary Medicinal Products.

Until the coming into force of the New Veterinary Regulation (2019/6/EC), all new products including generics had to perform an environmental risk assessment. For many commonly used types of products such as parasiticides and antibiotics, fate and effects data have become available.

With the experience gained it is now necessary to revisit some of the assumptions and to include new scientific findings into the guidelines. For example, there is growing evidence that the emission of substances used in companion animals is not negligible. Concepts for assessing the potential environmental risk of companion animal products are under discussion, starting with parasiticides used in dogs.

The details of exposure assessment have not been harmonised in VICH and individual approaches are used in the VICH regions. In Europe, due to changes in agriculture, additional exposure routes, such as free-range chicken or pigs, have become more relevant.

New types of medicines being developed include nanotechnologies, phages, and RNAi. Some of them might be good substitution candidates for older products with high impact on the environment. However, research is needed to identify (or exclude) potential environmental impacts and to develop targeted assessment methods. In Europe, a set of guidelines is being developed for novel therapies which includes initial provisions on considering the environmental impact.

The data generated in the past years also allow the scientific validation of assumptions applied in the guidelines. As an example, we will analyse the assumption that products with predicted concentrations in soil of less than 100 µg/kg are exempted from experimental testing unless other concerns apply.

The identification of risk mitigation measures to reduce the environmental impact of veterinary medicines is a continuing challenge. In addition, there is growing interest from farmers and veterinarians on the environmental impact of medicines they use. They need options to include this information when choosing the best product for their animal. This is especially important for e.g. protected areas with grazing projects or areas with a high frequency of dog walkers.

5.14.T-02 A Practical Framework for Leveraging In Silico Tools and Read-Across in Environmental Risk Assessment of Pharmaceuticals

Morgan Willming[1], Kristian Fried[1] and Daniel Dawson[1] (1)Integral Consulting Inc.

Environmental risk assessments (ERAs) of pharmaceuticals are required by regulatory agencies including the US Food and Drug Administration (FDA) and the European Medicines Agency (EMA). However, chemical-specific ecotoxicity and environmental fate data are frequently unavailable, particularly for novel compounds, orphan drugs, or pharmaceuticals with limited production volumes. Generating new experimental data to fill these gaps is time- and resource-intensive and may not always be warranted when existing computational tools and structured read-across approaches can adequately characterize risk. In silico tools and weight-of-evidence (WoE) approaches are particularly relevant for supporting categorical exclusions under FDA regulations and for refining Phase II ERAs under EMA guidance, where they may reduce or eliminate the need for higher-tier testing. Despite the availability of multiple in silico tools, practical guidance on how to strategically integrate them within an ERA framework remains limited.

This presentation proposes a practical framework for conducting pharmaceutical ERAs using publicly available in silico tools and WoE approaches. For exposure characterization, the framework highlights the use of iSTREEM for deriving predicted environmental concentrations (PECs) and the EPA Chemical Transformation Simulator (CTS) for evaluating phototransformation products. For effects assessment, the fish plasma model can support effects characterization, complemented by structured read-across approaches, receptor binding activity, and adverse outcome pathway (AOP) analysis to derive predicted no effect concentrations (PNECs). Key considerations are discussed, including read-across compound selection, tool limitations, how in silico approaches inform tiered testing decisions, and regulatory differences between FDA and EMA. Special attention is given to assessing estrogen-active and steroidal compounds, where heightened regulatory scrutiny may present unique challenges that can be addressed through tailored application of the available tools. This framework offers practitioners a structured approach to conducting defensible pharmaceutical ERAs while efficiently addressing data gaps across regulatory contexts.

5.14.T-03 The Use of Monitoring Data for Surface Waters in Europe in Pharmaceutical Risk Assessments: The Need To Ensure Those Data Are Reliable and Relevant

Iain Wilson[1] and Graham Merrington[1] (1)wca environment Ltd.

Measurements of pharmaceuticals in the environment are used for a wide range of purposes, from simple environmental status reporting to legally binding compliance monitoring and complex risk assessments. Compared with chemical ecotoxicity data, for which prescriptive frameworks of evaluation exist in many regulatory jurisdictions, these monitoring data, often termed chemical exposure data, generally receive only cursory assessment by practitioners. The evaluation of exposure datasets is not immune to the potential inconsistencies of expert judgments, introducing bias and bad practice, and leading to the drawing of spurious conclusions.

Exposure data should be evaluated for both reliability and relevance. Assessment of reliability refers to the inherent quality of the dataset, and evaluates the methods for sample collection, chemical analysis, and data processing steps. An understanding of the sampling design by which data were originally collected can help inform data processing decisions. This is especially important for micropollutants, such as pharmaceuticals, as exposure datasets are often fragmented and have been generated for many different purposes. Chemical exposure data relevancy assessment evaluates whether the dataset is appropriate for a specific end use or application; can it provide useful information for answering the questions that are posed by that application? This assessment typically considers the study design by which the data were originally collected and processed to establish what landscape and conditions are represented by the dataset and whether the dataset is appropriate for the purpose of aquatic risk assessment.

The CREED approach (Criteria for Reporting and Evaluating Exposure Datasets) was developed as part of a SETAC Technical Workshop in 2022, and provides ‘best practice’ for the evaluation of exposure data reliability and relevance. Here we provide examples of how CREED can be used to assess pharmaceutical monitoring data across Europe to support risk assessments, and what can happen if it is not used, and how that can influence the outcomes of risk assessments, through reference to European regulatory processes.

The approach means that data generators and researchers can understand how their measured pharmaceutical

data can be used for risk assessments purposes. Further, it ensures that existing exposure datasets may be evaluated to provide consistent and transparent assessments of potential pharmaceutical risks.

5.14.T-04 Emerging Contaminants in Drinking Water Source Regions: Quantifying Mixture Risk in Great Lakes Waterbodies

Emma VanderMeulen[1], tracie baker[1] and Bridget Baker[1] (1)University of Florida

Pharmaceuticals and personal care products (PPCPs) are contaminants of emerging concern detected in surface waters globally, entering aquatic systems through wastewater effluent, agricultural runoff, and improper disposal. The Lake Huron to Lake Erie Corridor (HEC) serves as drinking water source for over 40 million people, yet combined ecological risk from PPCP mixtures remains poorly characterized. Forty-six PPCPs were quantified across 14 sites in the HEC sampled in May 2025 and grouped into multivariate community profiles. Discharge-weighted loading estimates were calculated using USGS streamflow data to characterize corridor-scale contaminant inputs. Aquatic ecological risk was assessed for 19 compounds using a Risk Quotient (RQ) framework across five endpoint categories: apical, fish-specific, Daphnia, algae, and nonapical. Predicted no-effect concentrations were derived from published literature. Mixture risk was evaluated using concentration addition with compounds grouped by mode of action and summarized by profile. Three distinct PPCP profiles were identified. Median mixture RQ values remained below 1 for apical endpoints across all profiles (maximum mRQ = 0.109, Profile 3). For nonapical endpoints, ecological risk exceeded mRQ = 1 at 66% of Profile 3 sites, driven primarily by diltiazem via CYP19A2-mediated pathways. Standard apical risk assessments can underestimate PPCP mixture risk in the HEC. Loading estimates indicate diltiazem inputs are distributed across multiple tributary sources throughout the corridor, consistent with widespread occurrence across Profile 3 sites rather than a discrete point source. These findings highlight gaps in current ecological risk frameworks and underscore the need for nonapical endpoint data for pharmaceuticals in major drinking water source regions.

5.14.T-05 Bench-Scale Modeling of Therapeutic Oligonucleotide Biotransformation and Photolysis in Water Systems

Vanessa Maybruck[1], Ryan McKeown[1], Karl Linden[1] and Cresten Mansfeldt[1] (1)University of Colorado Boulder

Therapeutic oligonucleotides are a new class of gene therapy drugs comprising chemically-modified aptamers, antisense oligonucleotides, and small interfering RNAs. This new group of compounds offers promising solutions to both rare and common genetic diseases and is rapidly expanding to market (with 24 therapeutic oligonucleotides approved in the United States and >300 currently in clinical trials). Consequently, therapeutic oligonucleotides require consideration for environmental risk assessment. Previous research suggests that therapeutic oligonucleotides may cause adverse ecological effects, including chemical toxicity from modified groups and non-target hybridization in the environment. However, the fate of therapeutic oligonucleotides in wastewater and stream matrices and viable water treatment mechanisms for these compounds remain unknown. This research elucidates the biotransformation and photolytic potential of therapeutic oligonucleotides through bench-scale modeling in activated sludge, stream, and deionized water matrices. All experiments included controlled modifications to a stock bovine coronavirus (BCoV) DNA reverse transcript sequence and a therapeutic oligonucleotide currently on the market. Therapeutic oligonucleotides will be detected using an adapted and optimized quantitative polymerase chain reaction (qPCR) protocol. To account for biological

activity, batch culture experiments were conducted for raw and autoclaved conditions in activated sludge and stream matrices. Preliminary results indicate that biotransformation plays a likely role in the fate of therapeutic oligonucleotides but is notably dependent on the sequence modifications present. To account for oxidation, experiments are in progress to measure therapeutic oligonucleotide degradation under dark and direct photolysis conditions with a range of fluence values under UV254 light. Because UV254 light is frequently used for DNA inactivation in disinfection, therapeutic oligonucleotides are expected to degrade somewhat during direct photolysis, with degradation mediated by the modifications present. These experiments will enhance the mechanistic understanding of therapeutic oligonucleotide fate and removal mechanisms in wastewater, drinking water, water reuse, and surface water systems. Additionally, the results of these studies will inform the development of environmental risk assessments and treatment trains for an expanding class of pharmaceuticals.

Disclaimer/Disclosure: This work is funded by an NSF NRT (award number 2022138, through University of Colorado Boulder BioFrontiers Institute Integrated Data Science Fellowship), NSF GRFP (award number DGE 2040434), and NSF CAREER grant (award number 2542554). All findings/opinions are the authors' and not the NSF's.

5.14.T-06 Application of Probabilistic Emissions Modelling To Estimate UV Filter Concentrations at a Recreational Beach in Florida

Margaret Fleming[1], Thomas Federle[2], Donald Versteeg[3], Michael Gonsior[4], Andrew Heyes[5], Carys Mitchelmore[5] and Iain Davies[1] (1)Personal Care Products Council (PCPC), (2)Thomas W Federle LLC, (3)Ecostewardship LLC, (4)Catalan Institute for Water Research (ICRA), (5)University of Maryland Center for Environmental Science

UV filters (UVFs), the active ingredients in sunscreen products, are subject to scrutiny from the scientific and regulatory community due to their potential risk to organisms in aquatic compartments. To assess this risk, environmental exposures are best characterized by combining exposure modelling with well-designed monitoring studies. To support UVF risk assessment, a probabilistic model incorporating environmental fate processes and consumer habits and practices was developed to represent the recreational beach exposure pathway and predict the UVF emissions due to direct release of skin-applied sunscreen products to aquatic environments. When used in conjunction with site-specific inputs, including the volume of the swimming area and the hourly number of swimmers, the probabilistic emissions model can be used to predict dynamic UVF concentrations at a beach of interest. A joint monitoring and modelling study of UVF concentrations at Calusa Beach in Bahia Honda State Park in the Florida Keys was conducted to elucidate spatial and temporal UVF concentration trends and to provide a case study to evaluate the predictive ability of the probabilistic UVF emissions model. Two methods of estimating the number of hourly swimmers were assessed, the first based on photos taken during the monitoring study and the second based on cell data. Measured UVF concentrations were highest in the afternoon, when the number of swimmers peaked. Subsequently, as recreational activities declined, UVF concentrations significantly decreased due to dilution/dispersal. Model performance was represented by the ratios of the predicted median values (describing the log-normal distributions of modelled concentrations) to the average concentrations measured in triplicate water samples. The UVF emissions model performed well (i.e., within a factor of 4) at predicting measured concentrations for the five UVFs during peak recreational activity at two sampling sites. On average, the model overpredicted the measured values by a factor of 1.6 when using the photo method and by a factor of 1.7 when using the cell data method. The reasonable

agreement between the predicted and measured values indicates the probabilistic emissions model can be a useful tool for characterizing aquatic UVF exposure at recreational beaches. Furthermore, the cell data method is a promising approach to support the application of the emissions model to beaches without available monitoring data.

Pharmaceuticals and Personal Care Products: Innovations in Risk Assessment, Regulation and Science

5.14.P-Th197 The Potential for Atmospheric Transport of Contaminants to Remote Lakes: An Assessment Using COSMO-RS Solvation Theory

J. Mark Parnis[1] and Chris D. Metcalfe[2] (1)CEMC Trent University, (2)Trent University, Peterborough ON

Pharmaceuticals and personal-care products (PPCPs), pesticides, and per-and polyfluoroalkyl substances (PFAS) have been detected in lakes far from known point sources. These compounds may be transported into the atmosphere in the gas phase or associated with aerosols or particulates. Here, the CONductor-like Screening MOdel for Realistic Solvation (COSMO-RS) theory is used to estimate key partition ratios for selected chemicals from these classes and used to map their tendency to partition within the atmosphere under typical conditions. In cloud-free conditions, the target chemicals partition to one or more of the organic or aqueous phases of aerosols and the gaseous phase in air. Changing the pH of aerosols in the range 0–7 results in most chemicals shifting from one phase to another. Most acids and bases shift strongly to the water phase under ionizing conditions (i.e., pH 0 for bases and pH 7 for acids. Adjustments to the modelling for an increased volume in the water phase and changes in the pH of aerosols under cloudy conditions results in the prediction that most of these chemicals will partition into water droplets (i.e. rain) at some pH value between 0 and 7. It is proposed that wastewater treatment plants are point sources for PPCPs and possibly PFAS, while agricultural applications are the source of pesticides. Partitioning into the atmosphere and medium- or long-range transport, followed by wet deposition or direct diffusion could explain the presence of many of these chemicals in remote lakes.

5.14.P-Th198 Pharmaceutical Environmental Risk Assessment in Tropical Agricultural and Livestock Surface Waters of Costa Rica

Carlos E. Rodriguez-Rodriguez[1], Nicole Argeñal-Avendaño[1], Laura Brenes-Alfaro[1], Mario Masís-Mora[1], Paula Aguilar-Mora[1], Víctor Castro-Gutiérrez[1], Verónica Lizano-Fallas[1] and Elizabeth Carazo-Rojas[1] (1)Centro de Investigación en Contaminación Ambiental (CICA), Universidad de Costa Rica, 2060, San José, Costa Rica.

To address the global concern of emerging contaminants in rural ecosystems, an environmental risk assessment of pharmaceuticals was conducted in surface waters within an intensive pineapple-cultivating tropical region in Northern Costa Rica. A total of 58 surface water samples were collected from 22 sampling points and analyzed using UHPLC coupled to a triple quadrupole mass spectrometer (UHPLC-MS/MS).The monitoring revealed widespread contamination, confirming the presence of 15 distinct pharmaceuticals. Antibiotics and lifestyle drugs dominated the findings, with caffeine reaching a maximum concentration of 17.5 µg/L, signaling high anthropogenic pressure. Risks were evaluated through chronic toxicity (Hazard Quotient, HQ), acute toxicity (Toxic Unit, TU), and antibiotic resistance selection (HQRes) frameworks.The ecotoxicological assessment

determined that 10 of the 15 detected compounds posed a moderate-to-high chronic risk to aquatic life. Specifically, sulfathiazole, clarithromycin, caffeine, and ofloxacin emerged as high-risk compounds, consistently generating an HQ > 1. Furthermore, ciprofloxacin and clarithromycin posed a high risk for the environmental selection of antimicrobial resistance, representing a severe public health threat.While acute risk was seldom described for individual substances, it was primarily driven by complex pharmaceutical mixtures; clindamycin was a high-risk compound for fish in specific sites. Ultimately, these findings underscore that the ecological threat in tropical agricultural landscapes is overwhelmingly driven by antimicrobial agents. This highlights an urgent need for targeted surveillance and mitigation strategies to safeguard vulnerable tropical aquatic ecosystems.

Disclaimer/Disclosure: This work was supported by Servicio Fitosanitario del Estado (SFE), Costa Rica, Vicerrectoría de Investigación (Project 802-B5-500) and UCREA (Project 802-C4-990), both from the University of Costa Rica.

Recent Advances in Pesticide Risk Assessments for Non-Target Arthropods

5.15.P-Tu166 Advancing the Environmental Risk Assessment of Non-Target Arthropods by Identifying Vulnerable Taxa and Linking Effects to Ecological Function

Lorraine Maltby[1], Leonhard Bürger[2], Steven Droge[3], Daniel Paredes[4], Jose Paulo Sousa[4], Grzegorz Sowa[1], Louise Wipfler[3] and Andreas Focks[5] (1)University of Sheffield, (2)Osnabrück University, (3)Wageningen University and Research (WUR), (4)University of Coimbra, (5)University of Osnabrueck

The European Guidance Document on Terrestrial Ecotoxicology (SANCO/10329/2002) is almost 25 years old. Consequently, the European Commission has mandated the European Food Safety Authority to review the guidance for non-target arthropods. Within this framework, the AENEAS project was established to advance environmental risk assessment by accounting for the impact of pesticides on non-target arthropods and the consequences for ecosystem services and ecological functions.

Here, we describe the implementation of a protocol designed to link pesticide effects on non-target arthropods to potential impacts on key ecosystem services. We compiled a database of arthropods pivotal for pest control and pollination, sampled from six focal annual crops (wheat, barley, maize, oilseed rape, potato and beet) and three focal perennial crops (olive, apple and grape) across 37 EU Member States. Representative arthropod groups contributing to these ecosystem services were identified across crop types and across geographic zones, with separate analyses performed for ground-dwelling and foliar arthropods.

Trait-based analyses were employed to identify vulnerable taxa within representative families for two different exposure scenarios; these were combined with toxicity data to derive chemical-specific vulnerability indices. To assess the impact of chemical exposure on population dynamics within agricultural landscapes, we utilised population modelling platforms, specifically ALMaSS and Bumble-BEEHAVE. Effects on population abundance were translated into ecosystem functions using functional responses for pest control and simulated flower visits for pollination.

Our landscape-level assessments integrated subpopulation impacts (in-crop and off-crop) and landscape heterogeneity, including crop diversity and the proportion of natural habitat. The results indicate that standard test species do not necessarily belong to the most vulnerable representative arthropod families; indeed, they may

be less sensitive to insecticides than those providing critical pest control or pollination services. While population modelling platforms show significant potential for assessing pesticide impacts across diverse agricultural landscapes, technical limitations in these platforms currently restrict the immediate use of this protocol in regulatory risk assessment.

Disclaimer/Disclosure: This work was funded by the European Food Safety Authority

5.15.P-Tu167 Developing a Framework for Identifying Sentinel Taxa for the Non-Target Arthropod Risk Assessment Using Field Effect Studies – a Case Study With Carabidae Ground Beetles

Charlotte Elston[1], Saskia Aldershof[2], Ed Pilling[3] and Frank Bakker[4] (1)Syngenta, (2)Bioresearch & evaluation, (3)Corteva, (4)Bakker Onderzoeks Beheer

Non-target arthropod (NTA) field studies represent the highest tier of study available in the tiered regulatory process. Field studies have the highest degree of realism, but also a high degree of variability and unlike higher tier bee studies, NTA field studies are conducted with naturally occurring populations of multiple species. This results in large, complex datasets involving hundreds of different taxa with differing compositions,abundances and phenologies, as a result these studies can be difficult to interpret and ascertain what is a potential effect of a plant protection product (PPP) on populations and communities versus natural background and seasonal variability.
The compiled NTA field effect database and its analysis represent a powerful resource for the development of the future risk assessment scheme for NTAs both in Europe and elsewhere. In the first instance, it allows to derive recommendations for future field trial design and for its data analysis and interpretation. Further, the identification of sentinel taxa is not only relevant for the evaluation of field effect studies but also for the development of ecological models. Considering the spatial and temporal scale of NTA field studies and the number of taxa that are observed, ecological models are expected to gain in importance in the future NTA higher tier risk assessment. As it will not be feasible to develop models for all taxa potentially present in an area, a framework to understand the key representative taxa is therefore essential for model development. In addition, the database is valuable for analysing the spatial and temporal variability of taxa or ecological traits, thus making it a valuable resource for establishment of Normal Operating Ranges or/and Specific Protection Goals. We present a case study using Carabidae ground beetles, highlighting both the challenges of identifying sentinel taxa but also possible solutions including pooling of specie based on analysis of traits and chemical sensitivity.

5.15.P-Tu168 Two New Oral Toxicity Test Methods for Herbivorous Insects, Locusta migratoria (Orthoptera) and Spodoptera littoralis (Lepidoptera)

Stefan Kroder[1], Andreas Duffner[2], Jörg Leopold[3], Sonja Braaker[4], Charlotte Elston[5] and Heike Fremdt[6] (1)ADAMA Agriculture Germany, (2)Eurofins Agroscience Services Ecotox GmbH, (3)Ibacon GmbH, (4)BASF France S.A.S., (5)Syngenta, (6)Bayer AG

Standardized test methods are available for several arthropod species that are required within plant protection product (PPP) regulations of the European Union. These were adopted from methods of the International Organization for Biological and Integrated Control (IOBC) and are focused on species relevant for integrated

pest management (IPM) such as parasitoids and predators of pest species. These methods represent a wide range of terrestrial arthropods but test methodologies for herbivorous insects are lacking.
In the context of agricultural production, all pest insects are herbivorous species that damage crops due to their feeding behaviour. Conversely not all herbivorous species are pest insects and their exposure to PPPs is not yet fully covered yet in environmental safety assessments. A potential gap in the risk assessments for the oral exposure route has been raised in Europe and in the United States.
Lepidoptera and Orthoptera are insect orders abundant in agricultural landscapes. Orthoptera are folivores throughout their life cycle while Lepidoptera transform from folivorous caterpillars to nectar-feeding, pollinating butterflies or moths, meaning the possibility of oral exposure to PPPs for some species exists. The CropLife Europe expert group for non-target arthropods initiated preliminary method development work to assess effects of PPPs on these insects. Studies were conducted using toxic references with the laboratory species, Locusta migratoria (Orthoptera) and Spodoptera littoralis (Lepidoptera). The tests comprised an exposure phase of 48 hours (acute mortality), the development period and reproduction assessment. The acute and chronic results of these studies are presented and discussed with respect to their suitability, reliability, limitations and shortcomings. The criteria used for both herbivorous test systems include control mortality, sensitivity, oral uptake, handling, test duration, sex determination and feasibility of reproduction assessments. The ERx values based on treatment rate will be shown and measurement accuracy of fed leaf material as well as possible endpoints that can be derived from such a parameter will be discussed.

5.15.P-Tu169 Using Mobility Data for Terrestrial Invertebrates in Precision Application Risk Assessments

Dwayne Moore[1], R. Scott Teed[1], Alan Samel[1], Melanie Bottoms[2], Helen Thompson[2], Charlotte Elston[2] and Amund N. Løvik[3] (1)Stone Environmental Inc., (2)Syngenta Ltd, (3)Syngenta Ltd.

Current screening-level pesticide risk assessments assume that terrestrial invertebrates occur only on treated fields or at specified distances in the downwind spray drift zone. However, many terrestrial invertebrates are mobile during one or more life stages. Thus, individuals can move between treated areas, areas receiving drift, and unexposed areas. Further, with the advent of precision agriculture, only portions of crop fields can be treated rather than entire fields. Thus, a better understanding of how individuals move and forage in agroecosystems is required to develop refined exposure models for terrestrial invertebrate species. We have compiled a movements database for terrestrial invertebrates, including lepidopterans, coleopterans, non-Apis bees, and spiders. Such data can be used to develop spatially-explicit exposure models by combining pesticide applications and off-target transport maps with pollinator movement trajectories to estimate exposure at each location visited. The movements database includes relevant characteristics of test organisms (e.g., species; life stage; size; type of movement such as foraging, dispersal, diurnal movements, and mating), foraging range, preferred habitats, environment (e.g., habitat type; crop stage; date; spatial and temporal scales for movement recordings), experimental setup, methods, and other metadata. These data can be used to establish which movement models best describe observed movement patterns (e.g., random walk; correlated random walk; Lévy flights) and the key factors affecting movements (e.g., crop; season; environmental conditions). In this presentation, we will describe the movements database, discuss data gaps, and illustrate how movement data can be used in precision agriculture risk assessments for case study species.

5.15.P-Tu170 Species- and Exposure Route-Specific Effects of Lambda-Cyhalothrin on a Non-Target Pollinator, the Painted Lady Butterfly and a Target Pest Species, the Small Cabbage White Butterfly

Chloe Sieg[1], Frank Green[1], Eric Peterson[2], Maxime Vaugeois[3] and Philip Smith[1] (1)Texas Tech University, (2)Syngenta Crop Protection, (3)Syngenta Ltd

Non-target arthropods in agricultural systems may be exposed to insecticides through direct spray, off field drift, and/or contaminated host plants. Despite increasing concern surrounding butterfly population declines, limited studies are available addressing the sensitivity of non-target Lepidoptera to pesticides, particularly across multiple life stages and exposure routes. This study examines the effects of lambda-cyhalothrin, a widely used pyrethroid insecticide, on the painted lady butterfly (Vanessa cardui), a non-target species, and the small cabbage white butterfly (Pieris rapae), an agricultural pest species. Both species are relatively well represented in butterfly pesticide toxicity literature, allowing meaningful comparisons to broader trends in non-target arthropod pesticide risk.

Effects of lambda-cyhalothrin on V. cardui were evaluated across five developmental stages, including three larval instars, pupae, and adults. Both contact and dietary exposure routes were assessed. Dose-response analyses revealed substantial differences in susceptibility among developmental stages and exposure methods. Early larval instars were generally more sensitive than later stages, while contact exposure consistently produced greater toxic effects than dietary exposure. Sublethal responses observed following exposure included decreased growth and food avoidance. Comparison of these results with those obtained from similar experiments with P. rapae could lend insight into species-specific differences in susceptibility between a non-target butterfly species and an agricultural pest.

5.15.P-Tu171 Biologically Informed Models for Honey Bee Acute Toxicity

Nicholas Geitner[1], Charlotte Elston[1], Jacob M Riveron[1] and Conal Aitken[1] (1)Syngenta, LLC

Predicting honey bee (Apis mellifera) acute toxicity is central to ecological risk assessment and to prioritizing candidate agrochemicals earlier in development. Quantitative structure–activity relationship (QSAR) models are increasingly used to support screening, yet models based primarily on chemical structure may miss biological drivers of internal exposure, limiting both predictive performance and the ability to generate actionable biological insight.

We present a biologically informed modeling framework to predict honey bee acute oral and contact median lethal dose (LD50) values from standard acute toxicity screening studies by combining structure-based descriptors with honey bee–relevant toxicokinetic information. In vivo whole-organism measurements were used to derive metabolism- and elimination-related endpoints, including kinetic clearance rates, and these endpoints were incorporated as additional predictors alongside chemical descriptors. Acute toxicity data were assembled from public sources and internal studies; results are presented as aggregated performance and interpretation summaries. Model performance was evaluated using external holdout testing based on publicly available substances to assess generalization beyond the training chemistry space.

Across external holdouts, adding in vivo kinetic clearance endpoints increased overall predictive accuracy relative to structure-only baselines and improved interpretability by identifying when toxicokinetics are likely to drive acute outcomes. Adding bee-relevant clearance to structure-based models improves both predictive accuracy and mechanistic interpretability across external evaluations. The main takeaway is simple: clearance in

honey bees frequently differs—often substantially—from clearance in commonly studied pest insects and other surrogate taxa, and those differences translate into meaningful changes in internal exposure over acute timeframes. In turn, that can shift LD50 predictions, chemical ranking, and hazard-category assignments, especially when toxicokinetics is the limiting factor rather than intrinsic potency. We conclude with practical recommendations for incorporating bee-relevant toxicokinetic endpoints into new approach methodologies used for pollinator safety evaluation and for benchmarking biologically informed models.

Statistical Approaches in Environmental Toxicology: Recent Developments and Future Opportunities

5.16.T-01 Better Alternatives Than Normalizing To Control: Case Studies With Algae Toxicity and Dose-Response Analysis

Christian Ritz[1] (1)National Institute of Public Health

In ecotoxicology growth inhibition is a commonly used endpoint for algal tests. Growth inhibition is not observed directly but derived
from a growth rate data through normalization using control group data. Normalization of growth rates introduces correlation. Specifically, the resulting growth inhibition data are not mutually independent, as was the case for the growth rate data, because they are all divided by the same average of control measurements. Ignoring the correlation in the statistical dose-response modelling of growth inhibition data may affect the resulting the parameter estimates. However, despite being a commonly used procedure in ecotoxicology, shortcomings of the normalization approach have not been investigated much in the literature.

One solution is an improved but non-standard dose-response analysis where correlations were approximated. This analysis seems not to have been widely used, possibly because there was no readily available statistical software. Moreover, this improved analysis was only applied to a few data examples without any detailed investigation of its advantages. Also, in case normalization is based on values, which are not subject to uncertainty, the normalization will not impact estimation of effective dose (ED) values or the corresponding standard errors. In practice normalization is usually based on control data, such as an average of three or six replicates. Consequently, normalization comes with uncertainty. Apart from these scattered pieces of insight, it remains unresolved to which extent normalization impacts the estimation of relevant ED values.

Based on both theoretical and empirical results, this presentation will show that it is preferable to incorporate normalization as part of the statistical analysis or, even better, entirely avoid normalization in the first place. Using a model based on growth rates will allow estimation of ED values for growth inhibition while avoiding downwards biased estimates and too small standard errors that could both have resulted from using normalization in combination with a standard dose-response analysis.

5.16.T-02 Multilevel Modelling for Integrating Dose-Response Data From Multiple Studies

Clare Kilgour[1], Brian Pyper[2], Ryan Hill[2] and Norm Healey[2] (1)University of British Columbia (UBC),

(2)Azimuth Consulting Group Inc.

Dose–response (D-R) assessment is one of the four fundamental components of risk assessment identified by the US National Research Council (1983) "Red Book" and involves estimating the relationship between the exposure dose of a substance and the potential adverse effects on organisms. Current best practice emphasizes D-R modelling to estimate exposure concentrations or doses associated with specified levels of impairment (e.g., IDx values), rather than reliance on hypothesis-testing endpoints such as NOAELs or LOAELs. While established guidance and tools for fitting D-R models to data from individual studies are well documented, approaches for integrating data across multiple studies remain less developed, yet are increasingly important as ecotoxicology and risk assessment continue to reduce animal testing and maximize the utility of existing studies. Here, we demonstrate methods to extend and strengthen D-R assessments using multilevel models (i.e., mixed-effects models in a frequentist statistical context and hierarchical models in a Bayesian context) to integrate toxicological data extracted from six published studies describing the effects of oral copper exposure on reduced egg production in birds. Multilevel models account for overall treatment effects as well as variability among studies, thereby providing broader inferences regarding the D-R relationship than analyses based on individual studies alone. We illustrate a step-wise approach to model development and selection that included comparing alternative random-effects structures for studies, assessment of the D-R curve using generalized additive models, and finally casting the preferred model in a Bayesian framework to better account for uncertainties. The preferred multi-study model provided an estimate of the copper concentration most likely to produce a specified level of effect (e.g., ID20), whereas modelling of individual studies yielded a range of plausible ID20 values. The results demonstrate the utility of multilevel D-R modelling for integrating toxicological evidence across studies and improving estimation of adverse-effect thresholds and associated uncertainty in ecological risk assessment.

5.16.T-03 Are the EPA Aquatic Life Benchmarks for Pesticides Protective for Aquatic Invertebrates

John Stark[1] (1)Washington State University

EPA develops measures to determine concentrations of chemicals in aquatic ecosystems that are protective of aquatic organisms. The Aquatic Life Criteria (ALC) is the scientifically established standard that defines the maximum concentration of a pollutant in water that is considered safe for aquatic life. An Aquatic Life Benchmark (ALB) is an informational value used when data is limited. Very few ALCs have been developed thus far for pesticides and other chemicals. However, more ALBs have been developed. In this study, I asked – Are the EPA ALBs protective for aquatic invertebrates. To answer this question, I evaluated eight data sets that I had previously published on acute mortality of Cladocerans to various pesticides and for which EPA had developed ALBs. I developed concentration-response curves and compared where the ALBs were located, or not located, on these curves. The assumption I made was that the EPA ALBs would be protective for Cladocerans exposed to pesticides. What I found instead was that some of the ALBs were completely protective of Cladocerans, others would result in Cladoceran extirpation and others would result in a wide range of mortality. Results of this study indicate that the ALB process may be flawed and should be reevaluated.

5.16.T-04 Hybrid Method Benchmark Dose Estimation With Heterogeneous Variance Structures for Continuous Toxicological Endpoints

Jens Riis Baalkilde[1] and Signe M. Jensen[1] (1)University of Copenhagen

The benchmark dose (BMD) methodology is widely used in environmental toxicology and risk assessment to derive safe exposure levels from dose-response experiments. For continuous endpoints, the hybrid method is commonly applied, but current implementations generally assume constant residual variance across all dose levels. In practice, however, toxicological datasets often show heteroscedasticity, which may influence both BMD and benchmark dose lower limit (BMDL) estimation.

This presentation introduces an extension of the hybrid BMD framework that allows the variance to vary as a function of the dose and/or the fitted dose-response relationship. The approach combines flexible variance structures with standard nonlinear dose-response models and integrates them directly into the hybrid method BMD estimation.

The presentation will illustrate the proposed framework using a case study and simulations covering multiple variance scenarios, dose-response curves, and experimental designs results.

The simulations show that accounting for heterogeneous variance can substantially reduce bias in BMD estimation and improve BMDL coverage compared with classic fixed-variance models. Results also highlight that model averaging over dose-response curves alone may not sufficiently address model misspecification when variance heterogeneity is present.

The proposed framework provides a flexible and biologically realistic extension of current hybrid BMD methodology that may improve reliability of continuous endpoint risk assessment in regulatory toxicology.

5.16.T-05 Bayesian Benchmark Dose Modeling – a Powerful Tool To Quantify Uncertainty in Dose-Response Assessment for Human Health and Ecological Risk Assessments

Kan Shao[1] (1)Indiana University Bloomington

The benchmark dose (BMD) methodology has fundamentally transformed dose-response analysis and is now the standard approach for deriving points of departure for human health toxicological reference values (TRVs). However, despite its widespread adoption in human health risk assessment, BMD methods have been less widely applied in ecological risk assessment, where accurate characterization of dose-response relationships is arguably even more critical. Unlike human health assessments, where uncertainty factors are applied to the point of departure, ecological TRVs are typically derived directly from the dose-response relationship itself. Consequently, transparency and rigorous characterization of uncertainty are especially important in ecological applications.

Traditional frequentist BMD methods, although widely used, can struggle to fully characterize the probabilistic complexities of toxicological data. Consequently, Bayesian BMD modeling has gained substantial momentum over recent years due to its distinct methodological advantages. These advantages include the ability to

seamlessly integrate multi-study data, incorporate prior biological knowledge, and, most crucially, its robust capability to rigorously quantify uncertainties originating from a wide array of sources.

In this presentation, I will systematically demonstrate how the Bayesian BMD framework can be implemented as a comprehensive tool to quantify multiple layers of uncertainty in dose-response assessment. First, I will explore the quantification of uncertainties inherent in the underlying dose-response data itself, addressing issues such as sample size limitations and intra-study biological variability. Second, the presentation will address model uncertainty, showcasing how Bayesian model averaging provides a statistically sound alternative to selecting a single "best" model, thereby reducing model dependence. Finally, I will detail how the Bayesian approach can evaluate variabilities and uncertainties among diverse studies, offering a cohesive strategy for meta-analysis in toxicological evaluations. Each of these critical functions will be practically illustrated through specific, real-world case studies.

Collectively, the examples will demonstrate how broader application of BMD methods, and Bayesian BMD approaches in particular, can improve the accuracy, transparency, and scientific rigor of dose-response assessment for ecological risk assessment.

5.16.T-06 Multivariate Diagnostic and Screening Level Risk Prioritization of Emerging Contaminants in Canadian Biosolids

Emile Habimana[1], Justine Fontaine[1], Sarah Gewurtz[2] and Sebastien Sauve[3] (1)Université de Montréal, (2)Environment and Climate Change Canada (ECCC), (3)University of Montreal (UdeM)

Sewage sludge provides essential soil nutrients but introduces complex mixtures of contaminants of emerging concern (CECs) whose hazards and toxicity post biosolid application remain insufficiently characterized. This study asks: Which CECs drive composition differences in Canadian sewage sludge, and how can hazards and risks be integrated to prioritize monitoring?

We quantified 110 CECs in 80 sludge samples from 29 Canadian municipalities using UHPLC and HRMS Orbitrap. Given skewed data, we applied multivariate methods—Spearman’s rank correlation, non-metric multidimensional scaling (NMDS), permutational multivariate analysis of variance (PERMANOVA), permutational analysis of multivariate dispersions (PERMDISP), and principal component analysis (PCA)—to assess compositional trends. Indicator species analysis (IndVal) identified group-specific contaminants, while multi-criteria decision analysis (MCDA) combined occurrence, persistence, bioaccumulation, and toxicity (OPBT) with risk quotients (RQ) under Canadian and European frameworks.

Results showed 81 CECs in half of samples; 25 compounds exceeded several thousand µg/kg in at least one sample. PERMANOVA revealed municipal affiliation explained 48% of variance (pseudo-$F = 1.69$, $p = 0.001$), with PERMDISP confirming location-driven differences ($F = 0.78$, $p = 0.761$). Four municipal clusters emerged, determined by PC1 (opioids, anticonvulsants, herbicides) and PC2 (industrial chemicals, bisphenols, fungicides). 29 indicator compounds (IndVal $\geq 50\%$, $p \leq 0.05$) differentiated municipal footprints. The European RQ framework proved more prescriptive, identifying 1,3-diphenylguanidine, caffeine, amphetamine, levonorgestrel, 6PPD-quinone, progesterone, testosterone, and medroxyprogesterone acetate as higher-risk eight high-risk CECs ($RQ \geq 1$), whereas the Canadian framework flagged only 1,3-diphenylguanidine as high-risk.

MCDA, integrating occurrence (% detection frequency), persistence (DT50), bioaccumulation (log Kow), and toxicity (toxicity value), calculated hazard scores (HS). Macrolide antibiotics (azithromycin, clarithromycin, roxithromycin) exhibited the highest HS (> 0.90), followed by tamoxifen (0.82), triclocarban and 4-methylbenzylidene camphor (0.79), triclosan (0.78), and fentanyl, fluoxetine, methadone, and progesterone (0.76).

This data-driven framework integrates multivariate analysis with risk-based prioritization, providing 29 indicator compounds for regulatory monitoring and enforcement.

Disclaimer/Disclosure: This project was funded through a contract with the Quebec Ministry of the Environment, the Fight Against Climate Change, Wildlife and Parks) and a project of the RQRAD supported by the Quebec Ministry of Agriculture (MAPAQ) and the Quebec Research Fund (Quebec Research Fund - FRQ).

Statistical Approaches in Environmental Toxicology: Recent Developments and Future Opportunities

5.16.P-We290 Statistical Analysis of Ecotoxicology Data for Regulatory Purposes: An IEAM Special Series

Raoul Wolf[1], David Fox[2] and Jannicke Moe[3] (1)Norwegian Geotechnical Institute (NGI), (2)Environmetrics Australia, (3)Norwegian Institute for Water Research (NIVA)

Statistical methodologies and tools applicable to ecotoxicology have developed and improved over recent decades. Nevertheless, regulatory risk assessments still utilise statistical principles and approaches that are no longer state-of-the-art. SETAC meeting sessions dedicated to statistical methods have witnessed a high level of interest and discussion regarding the progress and applications of statistical methodologies. Many ecotoxicologists have expressed interest in the revision of the 2006 OECD document no. 54 ("Current approaches in the statistical analysis of ecotoxicity data: a guidance to application"). This guidance is no longer considered reflective of contemporary statistical methods or computational platforms used in ecotoxicology, and its revision process is ongoing.
Against this background, a call for papers for a Special Series in Integrated Environmental Assessment and Management (IEAM) was launched in autumn 2024 with manuscript submissions until summer 2025. The resulting series of 12 papers was published in the May 2026 issue.
The purpose of this Special Series was to provide an overview of the statistical ecotoxicology landscape and reflect on recent developments, processes and opinions. Relevant topics include (but are not limited to): similarities and differences of toxicity metrics (NOEC, BMD, NEC, ECX, NSEC, and more); developments and tools for dose-response modelling; developments and tools in SSD modelling (model averaging, mixture models); Bayesian vs. frequentist approaches; and case studies of novel statistical methodologies highlighting their benefits. We welcomed and encouraged contributions and viewpoints from members of all sectors, including academia, industry and government.
In this poster we give an overview of the series of papers, focusing on the variety of approaches, scientific novelties, and implications for regulatory ecotoxicology and risk assessment.

Disclaimer/Disclosure: R.W. received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101036756.

5.16.P-We291 The Benefits of Bayesian Statistics: Examples From the OECD Guidance 54 Annexes

Raoul Wolf[1], David Fox[2] and Jannicke Moe[3] (1)Norwegian Geotechnical Institute (NGI), (2)Environmetrics Australia, (3)Norwegian Institute for Water Research (NIVA)

OECD Document 54 ("Current Approaches in the Statistical Analysis of Ecotoxicity Data: A Guidance to Application"), first released in 2006, is being revised and will also include Bayesian methods alongside traditional frequentist approaches. The OECD document 54 annexes provide example datasets from OECD test guidelines 201 (algal growth inhibition), 202 (Daphnia acute immobilisation), 211 (Daphnia reproduction), and 215 (fish juvenile growth).
The revision reflects a broader shift in life sciences toward Bayesian statistics, valued for handling hierarchical, nonlinear, and data-limited scenarios, while offering transparent assumptions, improved uncertainty quantification, and reproducible workflows. Criticisms of Bayesian methods (higher data demand, greater uncertainty, and subjectivity due to priors) will be addressed through intuitive workflows, checklists, and comparisons with frequentist results.
For concentration-response analysis, log-normal, log-logistic, and Weibull type I and II models were applied, with model choice guided by Bayesian cross-validation. ECX values and credible intervals were derived from posterior distributions. Hypothesis testing used Bayesian hierarchical regression (analogous to ANOVA), with partial pooling to reduce false positives/negatives and effect significance assessed via posterior draws and the ROPE principle, yielding de facto NOEC/LOEC values.
Validation included prior-posterior and posterior-predictive checks, plus sensitivity analyses to detect prior-likelihood conflicts. Results showed Bayesian methods robustly produced EC/LCX and NOEC/LOEC values across datasets, with credible intervals automatically capturing uncertainty from data variability, sample size, and priors. While strong priors influenced some parameters, final endpoints remained unaffected.
Overall, Bayesian analysis matched frequentist outcomes in most cases and offered advantages in challenging contexts (e.g., unwanted mortality, small sample sizes). The methodology meets regulatory requirements, demonstrating that Bayesian approaches are not more data-demanding, uncertain, or subjective than frequentist ones; and can even reduce uncertainty in some cases. The study encourages scientists and regulators to adopt Bayesian methods for standard ecotoxicity data analysis, highlighting their robustness, transparency, and potential to improve regulatory statistics.

5.16.P-We292 A Two-Stage Simulation-Based Method for Optimal Experimental Design in Benchmark Dose Estimation

Davood Poursina[1], Yichuan Bai[2] and Xiaoyi Sopko[3] (1)Corteva Agriscience, (2)Phd Student, (3)Sr data scientist

The accuracy of Benchmark Dose (BMD) estimation, a modern statistical approach in risk assessment, is fundamentally determined by the study's experimental design. The challenge lies in selecting an optimal set of dose levels from a vast search space, as poor choices can lead to biased or highly variable results and inefficient use of resources. This work presents a novel computational framework to identify optimal dose level selection that minimize estimation error while ensuring a high probability of a successful BMD estimation.

Our approach utilizes a two-stage random search algorithm. An initial global search broadly explores the dose-combination space to identify promising regions, followed by a focused local search that uses a k-nearest neighbor method to pinpoint precise, optimal dose selection. BMD estimation is performed using Bayesian Model Averaging. To address real-world uncertainty, we conduct a sensitivity analysis using K-means clustering to select designs that are robust to misspecification of the underlying dose-response model parameters.
Results from simulation studies based on some prior assumption about the parameters values show that the algorithm successfully identifies optimal designs, with the Mean Squared Error (MSE) of the BMD estimate decreasing as the number of dose levels increases. Importantly, the sensitivity analysis identified designs that remained stable and effective even when the true BMD was misspecified by up to 20%.
This methodology provides practitioners with a computationally efficient and powerful tool to develop robust experimental designs for BMD estimation. By accounting for uncertainty in prior assumptions, this approach advances the field by enabling the design of more accurate, reliable, and resource-efficient toxicological studies.

5.16.P-We293 Evaluating AI-Assisted Bayesian Network Development Through Comparison With an Expert-Developed Ecological Relative Risk Model

Una Jermilova[1], Wayne Landis[2] and Jasen Nelson[3] (1)Trent University, (2)Western Washington University, (3)Science Advisory Board for Contaminated Sites

Bayesian network relative risk models (BN-RRMs) are increasingly used in environmental risk assessment because they can integrate diverse datasets, represent uncertainty, and evaluate complex ecological relationships. However, developing BN-RRMs remains time-intensive and technically challenging which has slowed their broader adoption among practitioners and decision-makers. Recent advances in artificial intelligence (AI) may help streamline model development, but the reliability and defensibility of AI-assisted BN construction is largely unexplored.
We present a web-based BN-RRM application that uses AI-assisted workflows to support model development, particularly the conditional probability table (CPT) generation from environmental datasets. Using a previously published BN-RRM developed for mercury exposure and risk in the Mackenzie Basin as a case study (Jermilova et al. 2025), we compare AI-assisted model outputs against the non-AI, expert-developed model. The comparison evaluates whether AI-assisted workflows can reproduce key components of published BN-RRMs, including network structure, risk rankings, sensitivity drivers, and scenario responses. We also assess the extent to which expert review and refinement can transform an AI-assisted draft into a scientifically defensible alternate model suitable for environmental decision support.
Beyond model development, the application was designed to make BN-RRMs easier to explore, interpret, and communicate. Users can visually compare model predictions with observed outcomes, explore environmental observations through interactive mapping layers, explore visual representations of the CPTs, test alternative scenarios, and immediately evaluate how new data influence model behaviour. By combining these features within a web platform, the application has the potential to make BN-RRMs more accessible not only to technical users, but also to broader stakeholder and community audiences.

5.16.P-We294 Specifications for the Use of Quantitative Methods (Statistics) for Ecological Assessments and Management

Wayne Landis[1] (1)College of the Environment, Western Washinton University

The term “risk” is not in the title because many ecological assessments are not probabilistic. By definition risk entails probability and cause-effect pathways (see Fenton and Neil 2011). Only if the assessment incorporates probability and delineated causal pathways can it be labeled as a “risk” assessment. There are multiple examples of risk assessment using Bayesian networks, Monte Carlo simulation and structural equation modelling across the world to produce environmental assessments for managing a diversity of systems, such as in the Pacific Northwest, British Columbia, California, China, Africa and Europe. These assessments rely on a variety of datasets, from routine toxicity testing, measurements of contamination in the field, surveys of the occurrence and number of species, and extensive mapping. Often these data are summarized via statistical methods with assumptions that do not match the inherent properties ecological systems. These properties are sensitivity to initial conditions, dynamics, contingent on the landscape, and historicity. Gradients in exposure are the norm, and downstream events can affect upstream systems. Investigators in the field are limited by geography, access and safety in sampling and taxonomy makes identification of taxa to determine species composition lengthy. NOECs, SSDs, ANOVA, or indices (IBI) are used. However, the nature of ecological systems means that the assumptions that underlie these conventional approaches are violated. However, there are a variety of other tools that have been demonstrated to be capable of assessing patterns. Multivariate statistics have been a mainstay in the ecological literature. It has been demonstrated that multivariate and machine learning tools could detect treatment effects in a variety of experimental and field systems. Since the early 1990s Bayesian networks, structural equation modelling and other tools have been applied to numerous risk assessments. In many software packages AI tools are built in (Case Learning) for the analysis of data and sensitivity analysis is routine. S. Graham et al for estuaries in Australia and Mentzel et al for Great Barrier Reef as an ecosystem are excellent examples of what is possible. I propose that more recent data analysis tools be evaluated according to their ability to bring information to improve the predictions of risk with sensitivity to multiple stressors evaluated and the uncertainties clearly defined.

5.16.P-We295 Evaluating Post-Derailment PAH Concentration Trends in East Palestine Sediment Using Linear Mixed-Effects Modelling

Lindsey Covell[1] (1)ToxStrategies

On February 3, 2023, a freight train derailed near East Palestine, Ohio, releasing hazardous materials upon impact and during subsequent emergency vent-and-burn procedures. Among the contaminants of concern were polycyclic aromatic hydrocarbons (PAHs), combustion byproducts potentially generated during the ensuing fires. Extensive environmental monitoring was promptly initiated by local, state, and federal agencies, academic researchers, and Norfolk Southern contractors to characterize exposures across affected media. In response to ongoing public concern regarding continued environmental contamination, this study evaluated temporal trends in PAH concentrations in sediment samples collected along a nearby waterway, Sulphur Run, over a 36-month post-derailment monitoring period.

Sediment samples collected by the United States Environmental Protection Agency (USEPA) from locations along Sulphur Run between July 2023 and April 2025 were analyzed across five discrete sampling periods.

PAH concentrations were log-transformed prior to analysis to address the right-skewed distribution. A linear mixed-effects model was fitted with sampling date as a continuous fixed effect and sampling period as a random intercept to account for within-period correlation. As samples were not collected from fixed locations between periods, the random effect captures between-period variability in baseline PAH concentrations rather than repeated measures. A case bootstrap procedure (999 iterations) was used to generate 95% confidence intervals robust to non-normal residuals and the clustered sampling structure.

The model identified a statistically significant negative trend in log-transformed sediment PAH concentrations over time. The marginal R^2 indicated that time alone explained a modest proportion of total variance, while the substantially higher conditional R^2 demonstrated that the inclusion of sampling period as a random effect markedly improved model fit, reflecting considerable between-period variability in baseline concentrations. This highlights the importance of accounting for clustered sampling structure to limit residual error and potential inflation of the temporal trend significance. Collectively, these results demonstrate that PAH concentrations in USEPA sediment samples from Sulphur Run have significantly decreased between 2023 and 2025.

5.16.P-We296 The Relative Contributions of Contaminants to Environmental Risk in the Upper San Francisco Estuary

Emma Sharpe[1], Wayne Landis[2] and Shawn Acuna[3] (1)Blankinship & Associates Inc., (2)No Affiliation, (3)Metropolitan Water District of Southern California (MWD)

The Upper San Francisco Estuary (Sacramento-San Joaquin River Delta) is one of the largest estuaries in North America. Many organisms rely on this area for migration and nursery. The Delta is surrounded by urban, industrial, and agricultural land use and has a documented history of contamination from a variety of sources. In order to assess the overall ecological risk for pelagic fish and macroinvertebrate communities from such a complex suite of contaminants, a comprehensive and dynamic method is required. For this purpose, a Bayesian Network-Relative Risk Model (BN-RRM) was developed. Additionally, a unique model averaging approach was used to determine mixture toxicity using single chemical toxicity data and normalizing for specific ECx values. This approach is ideal for a multiple stressor regional-scale ecological risk assessment where there are complex relationships between variables. Environmental concentration data, used to estimated exposure, was downloaded from the California Environmental Data Exchange Network (CEDEN) and California Surface Water (SURF) databases and combined into a single dataset. Dose-response models connecting acetylcholinesterase inhibition to mortality in multiple fish species for malathion and diazinon were derived from Laetz et al. (2009). Dose-response models for chlorpyrifos and bifenthrin for silverside mortality were derived from Hutton et al. (2021). In the model, mixture additive equations were used to estimate toxicity of mixtures of these contaminants. Chinook salmon and Delta smelt were used for fish endpoints. Based on a sensitivity analysis comparing the modeled contaminants, mortality from mercury and mortality from a malathion and diazinon mixture has the most impact on fish abundance. The degree to which mortality pathway influenced fish abundance varied by risk region and model assumptions. This model can continue to be extended as sufficient dose-response data becomes available for additional contaminants.

5.16.P-We297 Deciding To Decide: Combining Acceptance and Utility in Bayesian

Ecotoxicology

Ullrika Sahlin[1], Niklas Vareman[1] and Carla Coelho[1] (1)Lund University

Risk assessment increasingly relies on quantitative methods to support regulatory decision making, yet the treatment of uncertainty remains heterogeneous, ranging from fully probabilistic analyses to the use of uncertainty factors and worst-case assumptions. This lack of integration limits transparency, reproducibility, and the effective use of available data. We propose a unified probabilistic–statistical framework that integrates different levels of uncertainty precision within a coherent assessment and decision-making structure. At the highest level, uncertainty is represented through full probability distributions using Bayesian statistical models, enabling inference on decision-relevant quantities conditional on both data and expert knowledge. Lower levels of precision are incorporated through conservative summaries derived from these probabilistic representations, ensuring consistency with existing regulatory practices while maintaining a clear link to underlying assumptions. To support decision making, the framework explicitly separates uncertainty characterisation from decision criteria, thereby enhancing transparency and reproducibility. It combines two complementary Bayesian decision-theoretic perspectives: an acceptance-based approach to determine whether an assessment is conclusive, and a utility-based approach to evaluate trade-offs in regulatory decisions. Conclusiveness is assessed against predefined criteria for practical certainty set by decision makers. The proposed approach is consistent with principles of uncertainty refinement and reduction in scientific assessment. We demonstrate its application to the derivation of regulatory thresholds using a LINEX loss function to balance the risks of over- and under-regulation, with uncertainty propagated from ecotoxicologically relevant endpoints derived from Benchmark Dose and Species Sensitivity Distribution modelling.

Disclaimer/Disclosure: Formas – a Swedish Research Council for Sustainable Development Grant 2025-02017 Ullrika Sahlin

5.16.P-We298 Toxval: A Unified Framework for Estimating Ecotoxicological Effect and No-Effect Metrics Across Statistical Paradigms

Ayla Pearson[1] and Rebecca Fisher[2] (1)No Affiliation, (2)Australian Institute of Marine Science

Contemporary ecotoxicology increasingly relies on model-based inference to derive toxicity metrics from concentration/dose-response data. However, the statistical tools used to estimate commonly used toxicity estimate remain fragmented, inconsistently defined, and often tied to specific modelling frameworks. These inconsistencies hinder transparency, reproducibility, and comparability in regulatory decision-making.
We present toxval, a new R package designed as a unified, flexible framework for estimating both effect-based (ECx) and no-effect metrics, including the recently proposed no-significant-effect concentration (NSEC). The NSEC provides a model-based alternative to the no-observed-effect-concentration (NOEC), overcoming key limitations by decoupling estimates from experimental design and enabling statistical inference while retaining the intuitive concept of "no observable effect."
The development of toxval is motivated by the need to operationalize NSEC estimation across both frequentist and Bayesian concentration/dose-response models, and to generalize this capability to a broader suite of toxicity metrics. In doing so, the package highlights a critical and often overlooked issue in ecotoxicology: ambiguity in the definition of "effect." ECx values, while widely used, depend on how effect is defined relative to controls, model structure, and scale of response, leading to inconsistencies in their derivation.

toxval addresses these challenges by providing:
(i) a consistent interface for extracting ECx and NSEC values from fitted models;
(ii) support for multiple model classes and inference frameworks (e.g., maximum likelihood, Bayesian MCMC); and
(iii) explicit, transparent definitions of effect and no-effect independent of model class.
Through illustrative examples, we demonstrate how harmonizing the derivation of ECx and NSEC across modelling approaches can improve interpretability and comparability of toxicity estimates. By integrating flexible modelling with standardized metric extraction, toxval contributes to modernizing ecotoxicological analysis and supports more transparent and reproducible environmental risk assessment.

5.16.P-We299 Using the Lowest Effect Concentration (LECx) To Establish Significant Thresholds for Toxicity Test Data and Water Quality Benchmarks

Josh Baker[1] (1)Rise Over Run Environmental

The lowest effect concentration (LECx), a hybrid endpoint using regression model and hypothesis test data evaluations, was used to characterize concentrations representing a no-effect threshold. Specifically, a regression model of sublethal data was used to calculate the toxicant concentration at which the level of effect observed was equal to the percent minimum significant difference from the control response (%MSD; as determined from a hypothesis test). Due to inherent differences (e.g., biological variation, statistical power) between different toxicity tests, significant effect levels ranged from 3% to 37% (i.e., LEC03 to LEC37). The LECx was compared to more commonly used arbitrary effect levels (i.e., EC10, EC20) in three different toxicant datasets containing toxicity results from various standardized toxicity test methods. Subsequently, the Hazard Concentration (HC5) was compared from Species Sensitivity Distributions for each of the toxicants using the LECx in comparison to other effect endpoints. The statistical and ecological significance of the LECx in comparison to other effect endpoints is explored.

Wastewater Surveillance for Environmental Health Monitoring

5.17.P-We258 Fate and Transport of per- and Polyfluoroalkyl Substances in an Estuarine Ecosystem Downstream of Municipal Wastewater Outfalls

Caitlin Neill[1], Kerri Ackerly[1], Elizabeth DiBona[1], Raegan Osentowski[1], Kathleen Roark[1] and Kristin Nielsen[1] (1)University of Texas Austin

Per- and polyfluoroalkyl substances (PFAS) are persistent and mobile contaminants frequently detected in aquatic environments downstream of municipal, industrial, and military facilities. Estuarine systems present complex environmental gradients that can influence PFAS transport, partitioning, and environmental fate, yet these processes remain understudied in wastewater-impacted coastal environments. We conducted a study investigating the occurrence, distribution, and fate of PFAS in an urbanized Texas estuary receiving effluent from six municipal wastewater treatment plants (WWTPs). Water and sediment samples as well as key environmental variables (e.g. salinity, dissolved organic carbon) were collected at multiple downstream locations associated with each outfall to evaluate PFAS concentrations, chemical composition, and partitioning behavior across the estuary. The results demonstrate spatial variability in PFAS concentrations and profiles

among sampling locations and reveal distinct patterns of partitioning between aqueous and sediment phases. These findings provide insight into the mechanisms controlling PFAS transport and fate in estuarine environments and improve understanding of the environmental behavior of PFAS in wastewater-impacted coastal ecosystems.

5.17.P-We259 First Survey of Estrogenic Activity in Municipal Wastewater Treatment Plant in the Province of Quebec, Canada

Julie Robitaille[1] and Éloïse Veilleux[1] (1)Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs (MELCCFP)

From 2021-2026, the Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs (MELCCFP) of the province of Quebec, Canada, is realising the initial characterisation of effluent of 28 large (> 17 500 – 50 000 m3/d) and 14 extra large (> 50 000 m3/d) municipal wastewater treatment plants (WWTPs) before their mandatory upgrade in infrastructure in the years to come. Wastewater sampling is done by the Direction des eaux usées of the ministry in partnership with the Centre des technologies de l'eau (Cteau). This characterisation includes the evaluation of traditional water quality parameters, multiple classes of chemicals (e.g. PFAS, pharmaceuticals, steroids, metals, flame retardant), as well as toxicity assays (D. magna, O. mykiss, P. promelas, C. Dubia). As WWTPs are known to be source of estrogenic substances (e.g. estrogen (E2), ethinylestradiol (EE2)), the Centre d'expertise en analyse environnementale du Québec (CEAEQ) of the ministry decided to test for the first time an in vitro bioassay-based method to assess estrogenic activity in effluents. This method in the process of internal standardization uses solid-phase extraction (SPE) on HLB Oasis column to concentrate the wastewater sample. Then, the sample's estrogenic activity is assessed with a luciferase assay with cell-lines of INDIGO Biosciences for the human estrogen receptor (ER). The activity of the sample is calculated in estrogen equivalent (EEQ) in ng/L by comparison to a standard of E2. The whole standardization process of the method will be shown including repeatability, quality controls and sample conservation. Moreover, estrogenic activity of 16 WWTPs across four seasons from 2025-2026 will be shown, as well as the treatment efficiency of 6 WWTPs done in 2023-2024. Already, results indicate the effluents can exhibit no estrogenic activity to levels as high as 39,2 ng/L EEQ. Furthermore, there is a clear impact of season on the treatment of estrogenic activity with the highest levels being observed in winter and the lowest typically found during summer. Overall, this first survey of estrogenic activity will help to evaluate the general levels found in effluents in the province and determine if some types of WWTPs have more efficient treatment. This will serve as a first proof-of-concept of this method to quantify estrogenic activity in WWTP effluent.

5.17.P-We260 Enhanced Quantification of Emerging UV Filter Contaminants Using an Optimized LC-MS/MS Technique

Logan Miller[1], Pinbo Zhang[2], Om Shrestha[1], Kathleen Luo[1], Xiomeng (Kate) Xia[1], Andy Sandy[1] and Evelyn Wang[1] (1)Shimadzu, (2)Shimdazu

Ultraviolet (UV) filter chemicals from sunscreens and personal care products are increasingly recognized as emerging contaminants of concern in drinking water. Their persistence and potential endocrine disrupting effects highlight the need for sensitive and reliable monitoring approaches. Quantifying these compounds at sub ng/L levels across diverse water matrices requires highly selective analytical methods. In this study, 20 UV filters were analyzed using a Shimadzu LCMS-8060NX triple quadrupole mass spectrometer (LC-MS/MS). The

objectives were to optimize quantitation to achieve ppt level detection without offline extraction and assess the occurrence of these compounds in multiple drinking water matrices. Chromatographic separation was performed on a Shim-pack Velox biphenyl column 2.7 µm, 2.1 × 100 mm with a Velox biphenyl delay column 2.7 µm, 2.1 × 50 mm to minimize background contamination, using water (10 mM ammonium acetate, 0.1% acetic acid) and methanol as mobile phases. Internal calibration curves were prepared in 60% methanol containing 0.1% formic acid with a minimum of nine calibrators per compound (n=4). Fortified water samples were analyzed to assess matrix performance, followed by analysis of unspiked samples for target compounds. Target analytes including keto avobenzone, enol avobenzone, cinoxate, ecamsule, ensulizole, homosalate, meradimate, octisalate, octocrylene, padimate O, benzophenone and its derivatives BP 1, BP-2, BP-3, BP-4, BP-6, BP-8, BP-10, BP-12, as well as enzacamene were optimized. Calibration curves showed excellent linearity ($R^2 > 0.99$) with calibrator accuracies within 80–120% and %RSD <10%. Direct injection of 100 µL without any sample extraction steps resulted in sub ppt LLOQs. Retention times and peak shapes remained stable on the Shim-pack Velox biphenyl columns throughout method development. Spikes with low/mid/high concentrations were prepared in five matrices: LC/MS reagent water, bottled water, filtered water, tap water, and well water. The results showed excellent accuracy in replicates with mean percent recoveries 80–120% and %RSD <10%, demonstrating excellent robustness of the method. Overall, this extraction free workflow enables high confidence monitoring of emerging UV filters at ng/L levels in treated drinking water. Ongoing work will extend applicability to additional matrices.

Disclaimer/Disclosure: For research use only. Not for use in diagnostic procedures.

5.17.P-We261 Combining Wastewater Surveillance and Other Testing Approaches for Monitoring Illicit Drug Use Across Connecticut, USA

Sara Nason[1], Haoran Yang[1], Raees Ahmad[1], Anuja Bharadwaj[1] and Robert Heimer[2] (1)Connecticut Agricultural Experiment Station, (2)Yale School of Public Health

There are many approaches for monitoring illicit drug use including analysis of community wastewater streams, products provided by people who use drugs, and samples from fatal and non-fatal overdoses, traffic stops, and drug seizures. In Connecticut, USA, we are initializing a program that will take a combined approach and compare data produced by different methods in cities across the state. Timing of wastewater surveillance will coincide with spatially coordinated sampling of individuals' drugs tested via FTIR. Initial analytical focus will be on emerging drugs such as medetomidine, nitazenes, xylazine, and kratom, alongside more traditional opioids and stimulants. We will present method development for integrating targeted and non-targeted approaches in wastewater surveillance, along with preliminary results from multiple data collection approaches in New Haven, CT.

5.17.P-We262 Development of an Analytical Method for New and Emerging Psychoactive Substances in Wastewater From Southern Ontario

Jeremy Hoare[1], Diana Cardenas[1], Leslie Bragg[1] and Mark Servos[1] (1)University of Waterloo

Wastewater-based epidemiology (WBE) is an increasingly important public health tool for monitoring patterns of drug consumption and identifying new and emerging psychoactive substances within communities. This information is used to support harm reduction efforts and provide insight

into trends in substance use. Quantification of drugs and their metabolites in wastewater is commonly performed using solid phase extraction (SPE) coupled with liquid chromatography tandem mass spectrometry (LC-MS/MS). However, wastewater influent is a complex and chemically diverse matrix, necessitating LC-MS/MS method optimization to achieve sufficient sensitivity, selectivity and robustness while minimizing matrix effects. The objective of this work is to develop and optimize a targeted LC-MS/MS method for the quantification of 20 new and emerging substances in wastewater influent, including nine benzodiazepines. Method development focuses on optimizing SPE conditions, chromatographic separation and mass spectrometric parameters to enhance analyte recovery and detection while minimizing matrix interference. Method validation will assess key performance metrics, including linearity, accuracy, precision, limits of detection and quantification, and matrix effects. Following optimization and validation, the method will be applied to influent samples collected from selected wastewater treatment plants in southern Ontario, Canada. Measured concentrations will be combined with influent flow rates and population to estimate community-level substance consumption through back-calculation. This work contributes to advancing analytical capabilities for monitoring emerging substances in wastewater and supports the application of WBE for informed public health decision-making.

5.17.P-We263 Exploring Relationships Between Established Drugs of Abuse and New Psychoactive Substances Through Wastewater-Based Surveillance During a Festival in Southern Ontario

Rashne Vakharia[1], Diana Cardenas[1], Emir Nazdrajić[1], Leslie Bragg[1], Mark Servos[1] and W. Scott Hopkins[1]
(1)University of Waterloo

The rise in drug use worldwide poses a significant public health issue due to its harmful effects on health and social wellbeing. In recent years, wastewater-based surveillance has emerged as a powerful tool for the anonymous monitoring of per capita consumption trends at the community level, offering a more cost-effective, accurate, and representative measure of drug use compared with hospital records, arrests, drug seizures, or surveys. In this approach, concentrations of human-excreted biomarkers are quantified in raw wastewater and can be combined with influent flow and, where relevant, population data to assess trends. Large public events and festivals have been associated with elevated or altered substance use. By monitoring compounds during and following such events, short-term changes in substance use can be captured and event-specific drug profiles can be characterized. In addition to informing public health planning and emergency and healthcare services, these findings can provide useful context for investigating new psychoactive substances (NPS), a large and rapidly evolving group of compounds that may occur as substitutes for or adulterants in traditional illicit drug supplies. In this study, 26 established drugs of abuse were quantified in wastewater samples collected during and following a city festival in Ontario, Canada, including stimulants, opioids, dissociatives, and other commonly used substances. Liquid chromatography-high-resolution mass spectrometry was also utilized to detect NPS in the same samples by screening MS and MS/MS data against a curated suspect list and relevant spectral libraries. Preliminary results showed mass loads for the 26 drugs of abuse ranging from 49-83,270 mg/day for opioids, 1,830-604,531 mg/day for stimulants, and 60,945-229,339 mg/day for antidepressants, with several compounds exhibiting temporal changes over the course of the event and into the post-event period. Initial suspect screening of one wastewater extract resulted in the tentative identification of numerous NPS, which are currently being reviewed. NPS detected across the study period will be related to trends observed in established drugs, helping to identify relationships between compounds, including those occurring concurrently or

displaying opposing trends, and improving our understanding of polysubstance use during the event.

5.17.P-We264 Detection of Opioids Within Municipal Wastewater Utilizing DNA Aptamer Biosensors

Matthew Cranney[1], Denina Simmons[1], Andrea Kirkwood[1] and Jean-Paul Desaulniers[1] (1)Ontario Tech University

In recent years there has been a significant increase in opioid-related deaths due to drug abuse in Canada with a major contributor to these deaths being overdose by illicit opioid use. Despite this, the monitoring of opioid use in communities has been difficult and poorly represented despite best efforts of health officials. The monitoring of opioid concentrations in municipal wastewater can be used to bridge this knowledge gap. To date, methods such as High Performance Liquid Chromatography and mass spectrometry have been utilized to detect opioids within wastewater, however, these methods require highly specialized instruments and training to achieve this detection and are not readily available to all laboratories. DNA aptamers can be used to avoid these drawbacks as they are relatively inexpensive and do not require the same specialized instruments and training to achieve detections. Aptamers are nucleic acid strands that possess sequences that can specifically bind to target molecules, allowing them to be used as biosensors for specific opioid targets within wastewater. The aim of this study is to develop several aptamer assays by which the concentration of different opioid targets (such as fentanyl, morphine, codeine, heroin, and oxycodone) can be measured within wastewater samples. Wastewater samples will be collected from several water treatment plants across Ontario, Canada, and filtered through 0.22µm filter paper to remove large particulates. Detections in the wastewater will be achieved by displacement of DNA strands conjoined to a fluorescent reporter. Binding to the target opioid, by the aptamer, will be indicated by a measurable increase in fluorescence. This can then be converted to opioid concentration by comparing it to opioid standard curves created from standards run in the same assay. The results of this study can be used to examine opioid use within comminutes and report to health officials. In addition, the assays created could serve as a method to perform detections for opioids in water samples on site.

5.17.P-We265 A High-Throughput Genotyping and Structural Analysis Framework for Viral Diversity Surveillance in Wastewater

Tomas de Melo[1], Andrea Kirkwood[1], Denina Simmons[1] and Jean-Paul Desaulnier[1] (1)Ontario Tech University

I present a high-throughput, adaptable framework for characterizing viral sequencing data from domestic wastewater. Beyond identifying genotypic diversity, the pipeline calculates population genetics metrics, including nucleotide diversity, Tajima's diversity index, and single-nucleotide variant frequencies, to identify loci under selection. Additionally, this pipeline also integrates automated 3D protein modelling using ColabFold (AlphaFold2) and ChimeraX to locally predict capsid structures (VP1) derived from wastewater and calculate their structural deviation (RMSD) from the reference strains. I demonstrate the utility of this approach by characterizing inter- and intra-genotypic diversity of Enterovirus and Norovirus GII across two distinct municipalities from 2021–2023, accurately resolving both highly similar (>95%, Norovirus GII) and divergent (>80%, Enterovirus) sequences.

5.17.P-We266 Using Generalized Additive Models With Proxy Indicators of Disease as a

Flexible Approach for Evaluating Wastewater Surveillance Data

Tomas de Melo[1], Andrea Kirkwood[1], Denina Simmons[1] and Jean-Paul Desaulnier[1] (1)Ontario Tech University

Wastewater surveillance (WWS) data is challenging to interpret due to inherent stochasticity that makes it difficult to identify trends using conventional correlation analyses. This data "noise" can mask the trend-signal in wastewater samples, leading to reduced confidence in results by undermining the accurate identification of shifting trends or outbreaks. To address this challenge, we applied generalized additive models (GAMs) to elucidate viral (Influenza A, Norovirus GII, and Enterovirus) dynamics across neighbouring municipalities near Toronto, Ontario. Additionally, we explored relationships between viral trends and student absenteeism as a proxy indicator for community disease burden across catchments. How data transformation affected the performance of the GAM were also evaluated. The GAMs performed exceptionally well as a descriptive tool and could explain up to 96% of the deviance observed in student absences when paired with WWS data. Our findings demonstrate the utility of GAMs, a flexible modelling approach for non-linear data, in managing the highly variable nature of WWS data and proxy indicators of disease. This approach could support integration of WWS into existing systems for assessing disease burden, to help inform public health strategies for reducing viral outbreaks in suburban communities.

5.17.P-We267 Detecting Sexually Transmitted and Blood-Borne Infections (STBBIs) in Wastewater Across Molecular and Microbiome Endpoints

Ashley Gedge[1], Andrea Kirkwood[1], Jean-Paul Desaulniers[1] and Denina Simmons[1] (1)Ontario Tech University

Sexually Transmitted and Blood-Borne Infections (STBBIs) remain a significant health concern, with an estimated 1 million infections acquired daily and 374 million new curable cases annually. Traditional surveillance methods relying on clinical testing likely underestimate true incidence due to asymptomatic infections, negative social stigma, and variability in healthcare access. Wastewater surveillance (WWS) offers complementary, population-level approach by detecting pathogens shed in urine and feces, enabling near real-time monitoring of community health. This study shows that STBBIs can be detected in wastewater across a variety of sewer sheds including bi-continental sites and compares methodological approaches for STBBI detection in wastewater. Preliminarily, sampling across multiple and bi-continental sites confirmed the presence of four STBBIs and their related genera (Chlamydia, Gonorrhea, Syphilis, and Human Papillomavirus) using RT-qPCR and 16s rRNA sequencing, with highest detection rates observed for HPV (33.7%), followed by Syphilis (4.5%), Chlamydia (2.2%), and Gonorrhea (1.1%). To ensure robust and reproducible detection, PEG-centrifugation and filtration were compared for recovery efficiency, consistency, and impacts on downstream molecular and microbiome analyses. Samples from Whitby (n=22) and Bowmanville (n=16) were processed using both methods and analyzed by RT-qPCR. Microbiome profiles from 16S rRNA sequencing were used to assess how effectively each method captured overall microbial complexity in wastewater. Results show that the concentration methods did not significantly differ in their ability to consistently quantify the STBBI targets however, a spike-in experiment confirmed PEG has better recovery (paired t-test, $p<0.001$) when targets are low in abundance. Microbiome profiles seem to differ between the two methods (PERMANOVA, $p<0.05$) with a trend towards filter recovering more rare genera. This study demonstrates the feasibility of integrating WWS into long-term STBBI surveillance and provides a recommendation for best practice to concentrate STBBI genetic material.

What's Next for Endangered Species Assessment of Plant Protection Products?

5.18.P-We019 Refining Potential Spatial Overlap for Species With Negligible In-Field Exposure to Agricultural Insecticide Products

Ashley St. Clair[1], Joshua Fischer[1], Gerco Hoogeweg[1] and Kristine LeRoy[1] (1)Corteva Agriscience

In the United States, a key step in assessing potential impacts of a pesticide or plant incorporated protectant to threatened and endangered (i.e., listed) species is characterizing the potential spatial overlap between a species' geographic range and crop footprint. The development of Geographic Information System (GIS)-based tools has increased the precision of these assessments, allowing for more focused evaluations and informing potential mitigation strategies. For a row crop, the spatial overlap analysis typically compares the species' geographic range with field locations where the crop is known to be cultivated. To account for potential off-field movement of pesticide or pollen containing insecticidal proteins, off-site transport distances are incorporated around the field area, thereby expanding the area considered for the overlap analysis. However, some species may have negligible in-field exposure due to a variety of factors. Such factors may include but are not limited to species biology, biology of the crop, and the intended uses of the product under evaluation. In such scenarios, potential exposure would be limited to off-field areas. Herein, we describe a refined approach to conduct a GIS-based species spatial overlap assessment under such conditions, providing a framework to better evaluate potential risk to listed species by focusing the assessment on areas with relevant exposure.

5.18.P-We020 Leveraging Machine Learning Techniques and High-Resolution Imagery for UDL Development

Raghu Vamshi[1], Kshitiz Dhakal[1], Nick Friedenberg[1] and Gerco Hoogeweg[2] (1)Corteva Agriscience, (2)Corteva Agriscience UK Limited.

Use Data Layers (UDLs) are a vital element in the United States (US) Endangered Species (ES) assessments representing potential pesticide use areas. Accurate spatial representation is essential for evaluating the overlap between these areas and locations of threatened or endangered (i.e., listed) species range and/or critical habitats. Advances in machine learning (ML), particularly deep learning models, have decreased the training data demands, time, and expense of classification modeling to address spatial challenges. We explored the practicality of a deep learning classification model (YOLOv8) to produce a non-agriculture nurseries UDL covering the continental US.

Nurseries encompass land uses such as retail nurseries, shade houses, horticultural facilities, and garden supply stores that cover the cultivation of ornamentals, shrubs, vines, and non-food trees in non-agricultural settings. They have a critical role in urban landscaping, yet their spatial representation remains weak on a national scale. This study introduces a deep learning framework for automated nursery detection using high-resolution aerial imagery across the US. The detection model was trained and validated on nursery locations guided by 10 state nursery registries spanning five distinct geographic regions – Northeast, Southeast, Midwest, Southwest, and West – to ensure broad geographic and climatic diversity. Training data were strategically sampled to encompass a range of field nursery operations, from large farms to small retail nurseries and comprised a variety of land cover typical of production nurseries, including greenhouse structures, shade houses, and outdoor growing areas. Model performance metrics demonstrate consistent detection accuracy across each region, underscoring the significance of regional similarities in agricultural image processing. The identified

nurseries, which were further refined using state-level nursery datasets and OpenStreetMap locations and compared with farm operations from the 2022 USDA Census of Agriculture, served as the basis for creating the nurseries UDL. The methodology is extensible to other non-agricultural facility types and demonstrates the effectiveness of deep learning algorithms for targeted, large-scale applications using publicly available high-resolution aerial imagery. Integration of these improved UDLs into ES assessments enhances both the accuracy and reliability of prospective pesticide use area delineation.

5.18.P-We021 Land Cover Context of EPA Core Maps and Pesticide Use Limitation Areas: Insights for Endangered Species Assessments

David Campana[1] and Spencer Mortensen[2] (1)Compliance Services International (CSI), (2)BASF SE

Endangered and threatened species (listed species) assessments for pesticides in plant protection products in the United States have undergone rapid evolution in recent years, driven by the U.S. Environmental Protection Agency's Herbicide, Insecticide, and Fungicide Strategies and associated implementation of spatially explicit mitigation frameworks. These approaches have increased both the complexity and transparency of endangered species (ES) assessments, emphasizing geospatial delineation of species ranges, designated critical habitat, and areas essential to species conservation and pesticide mitigation. Central to this effort is the development of "core maps" and corresponding Pesticide Use Limitation Areas (PULAs), which translate ecological considerations into actionable spatial constraints for pesticide use.

To support ongoing refinement of these frameworks, we conducted a national-scale geospatial analysis to quantify land cover composition within and surrounding EPA core maps across select species groupings. Using publicly available land cover datasets (e.g., National Land Cover Database) and consistent buffering distances, we evaluated the distribution and proximity of agricultural and non-agricultural land cover classes relative to mapped ES considerations. Analyses were stratified by species groups to assess variability in land cover composition and potential exposure-relevant landscapes.

Preliminary results indicate substantial heterogeneity in land cover composition both within and adjacent to mapped areas, with notable differences among species groups. In many cases, agricultural land cover types extend into or occur in close proximity to core maps, suggesting opportunities to better align mitigation strategies with real-world land use patterns. Conversely, non-agricultural land covers such as developed and natural vegetation classes represent a meaningful proportion of mapped areas, providing the opportunity to explore species-specific reliance on various land cover types.

These findings provide a quantitative foundation for improving translation of core maps into practical and effective mitigation measures, including refinement of PULAs, development of land cover-informed exposure assessments, and identification of areas where mitigation flexibility may be feasible. More broadly, this work supports continued advancement of spatially explicit ES assessment frameworks by integrating landscape context into regulatory decision-making.

5.18.P-We022 FESTF Lens: A Web Portal Providing Resources and Decisions Related to Pesticides and Endangered Species

David Campana[1], Ashlea Frank[1] and Tilghman Hall[2] (1)Compliance Services International (CSI), (2)Bayer Research & Development Services LLC

Since its formation in 1997, the FIFRA Endangered Species Task Force (FESTF) has provided essential data and insights at the intersection of pesticide regulation under FIFRA and the Endangered Species Act (ESA). FESTF aggregates and delivers a wide range of information on ESA-listed species, including their biological attributes from the US Fish and Wildlife Service and National Marine Fisheries, spatial data illustrating potential overlaps between pesticide use sites and ESA-listed species, measures aimed to mitigate pesticide exposure, and regulatory processes and decisions from the U.S. Environmental Protection Agency (EPA). These data, individually and in combination, can inform regulatory decision making at the FIFRA and ESA intersection, facilitate improvements in data availability and processing, and support practical implementation on the ground. To streamline access and support decision-making at national, state, and local levels, FESTF has developed Lens, a publicly accessible web portal. FESTF's Lens offers a one-stop resource for comprehensive, routinely updated data supporting pesticide regulation and endangered species to bring efficiencies to the FIFRA-ESA process. When integrated through FESTF Lens, these resources can support novel refinements and new analytical approaches by enabling more spatially explicit, biologically relevant, and decision-focused assessments. This poster will provide an overview of FESTF Lens and outline the various components and resources available.

5.18.P-We023 Updated Residue Unit Doses for Wildlife Exposed to Pesticides in Vegetative Dietary Items

Scott Teed[1], Dwayne Moore[1], Steven Levine[2] and Ismael Rodea-Palomares[3] (1)Stone Environmental Inc., (2)Bayer Crop Science, (3)Bayer US Holding LP

The Terrestrial Residue EXposure model (T-REX) developed by the US Environmental Protection Agency (EPA) is the standard model for estimating acute and chronic dietary risks of pesticides to birds and mammals. In T-REX, initial pesticide residue levels in wildlife dietary items are estimated using residue unit doses (RUDs) or nomograms. The data required to generate the RUDs (expressed as mg a.i./kg ww/lb a.i./acre) for dietary items on treated areas were collected from numerous spray trials that included measurements of pesticide concentrations immediately after application and the corresponding application rates. The approach assumes that initial pesticide concentrations are directly proportional to application rate and are not affected by pesticide, formulation, environmental conditions, application equipment and other factors. The current RUDs suffer from several deficiencies. For example, they are based on data from UTAB (Uptake/accumulation, translocation, adhesion, and biotransformation) data collected prior to the implementation of good laboratory practice (GLP) standards. In addition, older studies that pre-date GLP standards often employed pesticide application methods that are not representative of current practices (e.g., use of air induction nozzles to reduce spray drift). As such, we consider the vegetative nomograms used by US EPA are outdated. Updated RUDs are presented for vegetative dietary items to ensure the best available data are used in the pesticide regulatory process that now includes risk assessments for threatened and endangered species under the US Endangered Species Act, and the subsequent need to identify and implement early mitigations. We will present the results of a CropLife America funded project to collect vegetative residue data from GLP field studies conducted since

1990. To date 279 registrant studies have been collected and evaluated, resulting in a database containing 3,317 unique residue records. We filtered the data (e.g., 1995 – 2020; 0DAA1A only) and identified a robust 2,658 records suitable for use in developing RUDs. We will discuss the data collected, the statistical analyses conducted, the relationship between the RUDs and application rate, and the updated RUD results for vegetative dietary items.

Disclaimer/Disclosure: This work was funded by CropLife America. CropLife America represents the developers, manufacturers, formulators, and distributors of pesticides and plant science solutions for agriculture and pest management in the United States.

5.18.P-We024 Using Traits-Based Approaches and Population Modeling To Assess the Impacts of Plant Protection Products on Freshwater Mussels

Ines Haberle[1], Maxime Vaugeois[2] and Valery Forbes[3] (1)Ruder Boskovic Institute, (2)Syngenta Ltd, (3)Florida Atlantic University (FAU)

Refinements in assessing risks of plant protection products to threatened and endangered species have largely focused on refining exposure estimates. Despite earlier indications that jeopardy decisions under the FIFRA/ESA process would involve population modeling, there has been little, if any, incorporation of such models, and risk assessments performed in this context are largely based on simplistic measures of organismal-level toxicity. By incorporating other aspects of species biology – over and above toxicological sensitivity – population models can provide more realistic measures of species vulnerability as well as recovery potential. Our research develops a generalized individual-based population model (IBM) for freshwater mussels, a taxon experiencing global decline. This builds upon prior work that combined Dynamic Energy Budget (DEB) and life-history theory to capture sub-lethal individual effects of stressors across three mussel life-history strategies: opportunistic, equilibrium, and periodic.

The modeling approach integrates an individual DEB model into the IBM, parameterized for a representative species of each life-history category, to capture how changes in growth, maturation, and fecundity influence long-term population dynamics. The model is used to simulate a range of theoretical impact scenarios and physiological modes of action of plant protection products, while accounting for realistic environmental drivers, inter-individual variability, and intra-specific competition.

Results show that population-level outcomes differ across life-history categories, even when individual-level responses appear similar. We also explore how varying the timing of pesticide exposure influences population-level impacts for each life-history category. Opportunistic species seem more resilient due to faster generation turnover, supporting quicker recovery once pesticide exposure ceases. Equilibrium species may be more vulnerable due to their longer generation times and lower fecundity. Combining a traits-based approach with mechanistic population modeling may be especially helpful for assessing risks to listed species for which data are often severely limited.

6. Engineering, Remediation and Restoration

Case Studies and Approaches to Assessing Damages and Restoration from Oil and

Chemical Releases

6.01.T-01 State of the Chaudière River: 10 Years After the Lac-Mégantic Rail Disaster

Pascale Tremblay[1], Alexandra Gélinas[1], Dominic Vachon[1] and Maxime St-Martin[1] (1)Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs, Québec

On the night of July 6, 2013, a train carrying crude oil derailed in Lac-Mégantic (Quebec, Canada), causing an oil spill. Between 2013 and 2023, numerous environmental monitoring studies were carried out. In 2023, the ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs of Québec sampled sediments, benthic macroinvertebrates and fish in the Chaudière River to assess it's condition 10 years after the tragedy. From 2013 to 2023, petroleum hydrocarbon contamination in sediments decreased in both extent and measured concentrations. In rocky substrate sections, the river's higher flow conditions facilitated the dispersion of sediment contamination, which promoted the recovery of benthic macroinvertebrate communities as early as 2014. However, contamination levels remain a cause for concern in six areas of fine sediment accumulation located within the river's first few kilometres. Consequently, signs of recovery in the benthic macroinvertebrate community seamed slower or less apparent in these areas. Changes in the fish community also indicated that the condition of the Chaudière River has generally improved. However, high rates of fin erosion, which have persisted since 2016, suggest that environmental pressure is still present. In summary, the river recovery is more apparent in rocky substrate sections than in sedimentation areas. This unique study, which integrates several components of a freshwater ecosystem, is particularly important for understanding the processes of river recovery following a major oil spill.

6.01.T-02 Linking Biomarker Responses in Tree Swallows (Tachycineta bicolor) to Remediation of Contaminated Sediments in the Great Lakes

Megan Woodyard[1], Christine Custer[2], Thomas Custer[2], Paul Dummer[2], Natalie Karouna-Renier[3] and Cole Matson[4] (1)Department of Environmental Science, Baylor University, Waco, TX, (2)United States Geological Survey (USGS), Upper Midwest Environmental Sciences Center, (3)United States Geological Survey (USGS), Eastern Ecological Science Center, (4)Baylor University

In 2010, the Great Lakes Restoration Initiative (GLRI) was launched to accelerate international efforts addressing the physical, chemical, and biological impairment of Great Lakes ecosystems by anthropogenic activities, with an emphasis on clearly defined objectives, targeted actions, and scientifically based, quantifiable outcomes. Previously and directly under GLRI, remediation of contaminated sediments involving removal of submerged, contaminated material via environmental dredging, capping or covering, or some combination has been a popular, albeit expensive and laborious approach to reducing organismal exposures to contaminants and – theoretically – improving biological outcomes for wildlife in the Great Lakes. However, there is limited evidence directly linking contaminated sediment remediation to measurable biological outcomes, complicating evaluation of efforts and generally restricting quantitative targets of contaminated sediment remediation to physical, chemical, or fiscal endpoints under GLRI. Evidence linking contaminated sediment remediation to biological outcomes – ideally over space and time – is urgently needed to evaluate the effectiveness of contaminated sediment remediation in Great Lakes ecosystems and to justify investment in efforts going forward. This study examines links between contaminated sediment remediation metrics and biomarker responses in Great Lakes Tree Swallow (Tachycineta bicolor) nestlings, including with respect to spatial and

temporal dynamics, using a linear mixed model and quantitative coding of the public, online database of projects applied under GLRI. Results suggest that contaminated sediment remediation is significantly associated with positive biological outcomes with patterns and trends depending on spatial and temporal proximity of contaminated sediment remediation actions and species sampling. An ancillary benefit of this study is in identifying unifying themes across projects that could refine systemization of publicly available data for more efficient tracking of biological outcomes associated with specific remediation or restoration actions, in support of GLRI's mandate toward advancing public-facing accountability and coordination among partners. This study evaluates efforts to address biological impairment of Great Lakes ecosystems via contaminated sediment remediation and informs expectations for future contaminated sediment remediation efforts under GLRI.

Disclaimer/Disclosure: This research was possible using data on Great Lakes Tree Swallows (Tachycineta bicolor) nestlings collected by Thomas and Christine Custer as part of research by the United States Geological Survey (USGS) funded under the Great Lakes Restoration Initiative (GLRI).

6.01.T-03 Real-Time Oil Spill Response: A Field-Deployable Handheld Fluorescent Imaging and Data Platform

Jeff Steevens[1], Dong Xu[2], Biplab Poudel[2], Jiacheng Xie[2] and Rishi Patel[3] (1)U.S. Geological Survey (USGS), (2)University of Missouri, (3)Jordan Valley Innovation Center

Rapid characterization of oil is required for spill responders to minimize environmental effects and aid recovery efforts. Conventional methods, such as gas chromatography-mass spectrometry, require sample handling, extended analysis times, and are relatively expensive. Therefore, a field-based technique is required for analysis immediately after a spill to support decision-making on spill containment, guide sample selection and analysis, and support immediate risk reduction. Therefore, we developed a sample analysis platform using field-deployable handheld tools comprising a custom fluorescent imager, a cell-phone application, and a web platform. Water, soil, and sediment samples are extracted using standard solvent extraction and analyzed using a handheld device to capture fluorescent images. The device captures images of the samples using a 385 nm light-emitting diode (LED) and a camera, while simultaneously recording location, time, and user information. These images are transferred to a cell phone and processed by an application by extracting image information and uses a custom regression model. The model predicts oil concentration from a fluorescent image of the sample. The model has been trained and developed using three types of crude oil, including one from the Macondo oil formation and two from Azerbaijan, to represent a range of crude oil compositions. We used approximately 2000 images to train the model and test the model. Data from the cell phone application is synchronized with a web platform for long-term curation of field-collected data. Future field testing and demonstration of this oil characterization tool will target the oil spill response community with further expansion for citizen science applications.

6.01.T-04 The Development and Validation of a Passive Sampler for Petroleum Hydrocarbons as a Tool for Ocean Oil Spill Response Risk Assessment

Brent Pautler[1], Rashmi Chandra[2], Anh Pham[2], Keval Shah[3], Meiry Farag[3], Ian Siboo[3] and Kela Ashworth[1] (1)SiREM, (2)University of Waterloo, (3)Environment & Climate Change Canada

Passive sampling has been shown to present many advantages over conventional sampling methods for

quantifying the availability of many chemical compounds classes in sediment, groundwater, and surface water in terms of cost and data quality. Many passive sampling devices (PSDs) are configured to estimate contaminant bioavailability and toxicity to environmental receptors as they quantify freely dissolved contaminant concentrations as opposed to the total amount. Acute and chronic risks can then persist long after oil is no longer visible, from exposure to toxic chemicals through air, water, and/or food. Oil spill response, investigation, and cleanup are often needed to mitigate these potential risks, and PSDs have the potential to be a valuable tool to quantify chemical availability and exposures.

The dialysis-based PSD used in this study consists of a cylindrical stainless-steel container filled with 60 mL of water and covered with a membrane filter, which functions as the diffusion rate-limiting barrier. Laboratory mesocosms experiments were conducted with diesel and crude oils to assess i) the uptake rate of a range of dissolved fractions by the PSD, ii) how adsorption of these fractions on different membrane types affects the uptake, and iii) whether only the truly dissolved PHC fractions diffuse into the PSD. In addition, experiments were conducted at the Environment and Climate Change Canada facility, utilizing its large-scale oil spill wave tank to assess the influence of weathering, volatilization and dispersants on the performance of the PSD.

Results obtained thus far indicate that the PSD with a 0.4 μm silver membrane as the rate-limiting barrier is a promising sampler design. Uptakes of different PHC fractions by this PSD could be described by Fick's law of diffusion, and the adsorption on the membrane did not appreciably affect PHC diffusion into the sampler. When a non-aqueous phase liquid (NAPL) was present, the PHC concentration in the sampler equaled to the concentration of the dissolved PHC in the bulk solution, suggesting that the NAPL phase did not diffuse through the membrane. Additionally, preliminary results from a large-scale oil spill simulation experiment suggest that the PSD was able to capture the change in PHC concentration in the bulk water due to volatilization.

6.01.T-05 Use of Passive Samplers in the Nearshore Environment To Characterize Exposure of Water Column Resources to PAHs From a Light and a Heavy Crude Oil Spill

Daniel Hahn[1], Emily Pisarski[2], Susan Snyder[1] and Sarah Allan[1] (1)National Oceanic and Atmospheric Administration (NOAA), (2)National Centers for Coastal Ocean Science (NCCOS)

Silicone band passive samplers were used to evaluate oil bioavailability and exposure to water column organisms following two very different crude oil spills in Louisiana, one releasing a heavy sour crude and the other a more typical south Louisiana sweet crude. A high concentration of oil extraction, shipping, and refining has resulted in numerous oil spills of various sizes occurring in the region in recent decades. The Natural Resource Damage Assessment (NRDA) process quantifies injuries to natural resources from spills and scales these injuries to projects that restore for the losses from the spill. Data collected for two recent spills in Louisiana show how silicone band passive sampling devices can be used to estimate contaminant exposures and associated injuries to water column resources resulting from oil releases. While traditional grab samples only provide a snapshot of water concentrations, passive samplers characterize time-integrated exposure to bioavailable PAHs (polycyclic aromatic hydrocarbons) in water that organisms experience as a result of an oil spill. Following these spills, the uptake of PAHs in passive samplers was compared with observed shoreline and sediment oiling, in addition to site hydrology. Data collected in reference locations during these incidents highlight the direct increases in water column concentrations of PAHs resulting from acute releases of oil, while

comparison with data from background sites further away help put into context the low-level chronic contaminants vs the acutely elevated PAHs during a spill. Though results were variable across the both spill sites, exposures to the higher levels of PAHs measured during the spill are known to cause effects in water column organisms that range from direct mortality in sensitive species and life stages to sublethal effects.

6.01.T-06 Patterns of Reduced Growth and Elevated Contaminants in Juvenile Starry Flounder (Platichthys stellatus) From an Urban Estuary

Cathy Laetz[1] and Sarah Allan[1] (1)National Oceanic and Atmospheric Administration (NOAA)

Legacy pollutants such as PCBs and DDTs can adversely impact aquatic habitats and resident fish health long after their release into the environment. Measuring these impacts, as well as those from currently-used pollutants (i.e., PAHs) and other environmental stressors (i.e., temperature), is important for planning effective restoration and remediation actions in urban waterways. The Duwamish River, which drains highly urbanized and industrial areas of Seattle WA, is listed on the National Priorities List due to three adjoining Superfund Sites and has been the focus of intense remediation efforts to improve habitat conditions and fish health. In order to assess the impacts of contaminant exposure on the health of a common resident fish species, we sampled juvenile starry flounder (Platichthys stellatus) from sites in the lower 7-mile stretch of the river, upriver reference sites, and a nearby reference river. Individual fish metrics, including daily growth rates calculated from otolith measurements, were analyzed along with contaminant concentrations in composited whole bodies and stomach contents. Previous measurements of contaminant concentrations in sediments near fish collection sites were also used. Mixed effects models showed that fish growth rates were negatively correlated with whole-body PCBs and stomach content PAH concentrations, and temperature was not a significant confounding variable. Movement of juvenile starry flounder between sites, caused in part by daily tidal currents, likely contributed to observed patterns of whole-body and stomach content contaminants. Overall, these data showed that juvenile starry flounder accumulate contaminants that negatively impact fish growth. This study highlights the utility of juvenile starry flounder as a sentinel of river conditions, and demonstrates the continued impact of legacy pollutants in this urbanized waterway.

Disclaimer/Disclosure: This work was funded by NOAA's Office of Response and Restoration, Assessment and Restoration Division.

Case Studies and Approaches to Assessing Damages and Restoration from Oil and Chemical Releases

6.01.P-We080 Using Models To Help Establish Natural Resource Harms After Oil Spills

Nadia Martin[1] and Emily Mazur[2] (1)Industrial Economics Inc. (IEc), (2)Industrial Economics, Inc. (IEc)

Oil spills can cause a wide range of impacts to coastal habitats and species. Following oil spill events, these harms to natural resources are often assessed under applicable regulatory processes, such as the Oil Pollution Act in the United States or the International Oil Spill Pollution Compensation Fund. Requirements and processes to respond to oil spills, and remove or address lingering oil in the environment, are fairly straightforward. However, the approach to assessing any remaining harms to habitats and species, including

determining how much compensation may be needed to restore for those harms, is often more complex. Assessing ecosystem harms begins with field studies to collect environmental samples such as sediment, water, or tissue samples and to document observations of oiled flora and fauna. This site-specific data is essential to evaluating harms but is often insufficient to determine the full magnitude of impacts. As such, this talk will focus on how resource-specific (e.g., birds) and broader habitat models can be used in combination with field data to establish natural resource harms after oil spills. We will share insights from recent modeling applications including best practices as well as approaches to maximizing site-specific data and addressing data gaps. We will discuss the utility of streamlined models that can be reused across spill events versus when tailored site-specific models may be needed.

6.01.P-We081 Practical Case of Integrating Remediation With a Natural Resource Damage Assessment

Stephanie Maggio[1], Joy Mcgrath[1] and William Schew[1] (1)GHD

Contaminated site investigation/remediation activities can inform Natural Resource Damage Assessments (NRDAs) by identifying contaminated areas and determining the extent of the injuries. Despite being conducted under different regulatory frameworks that can vary in their requirements, timelines, and goals, there are often opportunities to incorporate NRDA considerations into remedial actions to reduce NRDA liability (e.g., habitat enhancement). This site, a tidal wetland situated in an industrial area, presented an opportunity to incorporate specific components from the remedial investigation and remedial design (RI/RD) to address and compensate for lost services within the NRDA. As part of the investigation, a "multiple lines of evidence" (MLOE) approach, considering sediment bulk chemistry, pore water chemistry, and toxicity testing, was applied to reduce the area that required remediation. In contrast, the NDRA was focused only on sediment bulk chemistry. Sediment concentrations were compared to thresholds known to cause harm to benthic invertebrates, and the resultant magnitude of likely effects was used to establish a service loss, and ultimately estimate natural resource damages. Damages, expressed as Discounted Service Years (DSAYs), were developed using a Habitat Equivalency Analysis (HEA) model to determine how much restoration was required to compensate for injuries resulting from residual contamination. This case study evaluated the impacts of integrating targeted habitat enhancement measures into the remedy by parameterizing the model with recovery rates commensurate with different habitat types. This case study also highlights the value of early and proactive consideration of NRDA requirements and restoration goals during remedial planning, demonstrating that integrated solutions can be most cost-effective, provide environmentally beneficial outcomes, and reduce overall NRDA liability.

6.01.P-We082 The Effects of Diluted Bitumen on the Structure and Function of Benthic Macroinvertebrate and Microbial Communities in Experimental River Mesocosms Modelling Pacific Salmon-Bearing Rivers

Diane Orihel[1], Jules Blais[2], Bruce Hollebone[3], Kevin Mumford[1], Jason Raine[4], Peter Hodson[1], O. Roland Akinseye[5], Charles Knapp[5], Mark Hanson[6] and Mikayla Melnick[6] (1)Queens University, (2)University of Ottawa, (3)ECCC, (4)Quesnel River Research Centre, University of Northern British Columbia, (5)University of Strathclyde, (6)University of Manitoba

Pipeline expansion in western Canada has increased the risk of oil spills and the ecological impacts of diluted bitumen (dilbit) on juvenile salmon and their food resources. We studied the effects of dilbit on benthic

macroinvertebrates in river mesocosms in British Columbia to understand the relationship between dilbit concentrations within river cobble and the abundance of invertebrate food items for chinook salmon (Oncorhynchus tshawytscha). Benthic macroinvertebrates were exposed to river cobble coated with a gradient of dilbit concentrations (n=7), and their survival and development were compared to controls (n=3) over two months. We measured the abundance, diversity and taxa richness of macrobenthics via colonization substrates and Hess samplers. Function was assessed via leaf litter bag decomposition and associated microbe analysis using Illumina 16S rRNA gene and ITS amplicon sequencing. Hess sampling yielded insufficient organisms for analysis. In contrast, all macroinvertebrate community metrics calculated from the leaf litter bags decreased significantly with increasing oil concentration, and oil concentration was a significant predictor of leaf litter degradation and mass loss. Further, leaf litter bags that included macroinvertebrates lost significantly more mass than those that excluded macroinvertebrates, indicating the contribution of macroinvertebrates to decomposition. Microbial analysis revealed treatment-dependent restructuring of bacterial and fungal assemblages along the oil gradient. Petroleum-associated bacteria were dominated by Massilia, Pseudomonas, Flavobacterium, and Cellvibrio, while fungi were enriched in Mycoarthris, Alatospora, Helotiales, and Oliveonia. Fungal taxa associated with petroleum made up 55–60% of the fungal community in several treatments, surpassing the bacterial petroleum degraders at 28–29%. Differential abundance screening identified hydrocarbon-responsive taxa with treatment-specific enrichment patterns across the dilbit gradient. Although bacterial and fungal alpha diversity metrics did not differ significantly across treatments, microbial composition indicated substantial ecological restructuring and selective enrichment of hydrocarbon-associated microorganisms under dilbit exposure. These findings demonstrate that dilbit contamination alters macroinvertebrate and microbial communities and may impair ecosystem processes linked to organic matter turnover and productivity of food webs in salmon rivers.

6.01.P-We083 Encasulation of Fungi To Enhance Bioaugmention Systems for PAH Remediation

Erica Babusci[1] and Claudia Gunsch[1] (1)Duke University

Polycyclic aromatic hydrocarbons (PAHs) are persistent, hydrophobic contaminants that accumulate in aquatic sediments and pose significant risks to environmental and human health. Bioaugmentation, the introduction of exogenous microbes to the environment to metabolize pollutants, offers a sustainable alternative to conventional remediation approaches, but its effectiveness is often limited by poor microbial survival and establishment under field conditions. To address these challenges, we are developing a microencapsulation strategy in which PAH-degrading microorganisms are immobilized within sodium alginate capsules formed via ionic gelation. This work focuses on fungi, an underutilized yet promising group for bioremediation due to their ability to produce broad-spectrum extracellular enzymes capable of transforming structurally complex compounds. Encapsulation provides a protective microenvironment that enables controlled fungal release while buffering cells from environmental stressors. Ongoing studies are evaluating how capsule formulation parameters influence fungal growth, metabolic activity, and PAH degradation using two isolates from a contaminated site representing distinct morphologies. Preliminary results indicate that encapsulation does not inhibit fungal growth or metabolic activity in simplified systems and, in some cases, enhances early growth dynamics, including reduced lag phases and improved persistence over time. However, encapsulated systems also exhibit significant sorption of PAHs to the alginate matrix, suggesting that encapsulation acts as a sink for nonpolar compounds. This dual role highlights a previously underexplored mechanism by which encapsulation can

simultaneously influence microbial performance and contaminant bioavailability, modifying degradation dynamics and mass transfer processes. Current work is expanding to encapsulated fungal-bacterial consortia in environmentally relevant systems to assess how encapsulation shapes microbial interactions, community stability, and PAH degradation. Together, these findings position microencapsulation as a promising precision microbiome engineering strategy that not only enhances microbial persistence but also modulates contaminant availability, offering a more controlled and effective approach for in situ bioremediation of PAH-contaminated sediments.

Damage Assessment: Applied Toxicology for Injury Determination

6.02.P-Th108 Relic Shell Model: Using Historic Sediment Core Data To Assess Injury to Fingernail Clams in a Metals-Impacted Lake

Jeffrey Morris[1] and Jamie Holmes[1] (1)Biodiversity Research Institute (BRI)

In support of an ongoing natural resource damage assessment (NRDA) in a freshwater lake impacted by metals and connected to a river in the Midwest, we quantified injury to fingernail clams (FNCs) and other benthic organisms using a Relic Shell Model (RSM). This RSM utilized historic data from deep sediment cores (as deep as 17 ft) that were collected throughout the lake from 20 sites. Core intervals were analyzed for metals and the presence of bivalve shells was noted. Because FNCs are endemic to this area and currently present in uncontaminated habitats, we assumed the absence of shells in a particular sediment interval indicated the concentrations of metals in the interval were toxic to FNCs. Our RSM utilized a binary logistic regression analysis to determine the probability of shells across a range of mixed metals hazard indices (HIs). As expected, the RSM predicted an absence of shells in sediments with higher metal HI values, indicating potential toxicity. We also compared our RSM predictions to measurements of bivalve abundance and survival in the lake across a range of metal HI values and other toxicological endpoints from the literature. Finally, we used our model to conduct a spatial analysis of injury and derive estimates of injured habitat (acres) and service loss that we used in a habitat equivalency analysis (HEA) calculation to determine damages due to the release of metals into this system.

6.02.P-Th109 Exposure to Contaminants Impacts Growth of Chinook Salmon Out-Migrating Through the Lower Duwamish River

Jessica Lundin[1], Sarah Allan[1] and Cathy Laetz[1] (1)National Oceanic and Atmospheric Administration (NOAA)

Juvenile Chinook salmon (Oncorhynchus tshawytscha) rely on estuarine habitats to support rapid growth and the transition from the freshwater to marine environment. Exposure to contaminants in estuaries can impact salmon health and survival. The Duwamish River is a contaminated estuary near Seattle, WA that is listed on the National Priorities List as three adjoining Superfund Sites. Though the current extent and concentration of contaminants is lower than historical levels, Chinook salmon continue to be exposed to contaminants as they out-migrate through the estuary. In this study, naturally produced juvenile Chinook salmon were collected from within and upstream of the Superfund areas on the Duwamish River in 2018. Tissue and stomach content concentrations of PCBs, DDTs, and PAHs were measured and associations between contaminant levels and growth rates were evaluated. A linear increase in PAH tissue concentration from upstream to downstream

through the assessment area and a reduction in growth associated with PAH concentrations in tissue samples was observed. The results of this study indicate that modern levels of contaminants in the Duwamish River are adversely affecting juvenile Chinook salmon.

6.02.P-Th110 Advances in Using LC-MS/MS To Quantify Biliary PAH Metabolites in Fishes as an Exposure Indicator for Natural Resource Damage Assessment

Susan Snyder[1], Sarah Allan[1], Daniel Hahn[1], Tracy Collier[2], Denis da Silva[1] and Emily Pisarski[3] (1)National Oceanic and Atmospheric Administration (NOAA), (2)Western Washington University, (3)National Centers for Coastal Ocean Science (NCCOS)

Biliary polycyclic aromatic hydrocarbon (PAH) metabolites are a common indicator of short-term exposure of fishes to these contaminants in aquatic environments. NOAA laboratories have developed and applied a new compound-specific liquid chromatography tandem mass spectrometry (LC-MS/MS) method that quantifies over 40 individual hydroxylated PAH (OHPAH) and alkyl-OHPAH metabolites in bile samples. This method is advantageous for Natural Resource Damage Assessment (NRDA) applications because it allows for more confident assessment of the magnitude of exposure and evaluation of PAH sources.

During two recent oil spills, we collected bile samples from fish that were exposed to different oil types (light sweet and heavy sour crude) at a range of oiling levels (from no observable oil to heavily oiled areas). Results indicate the LC-MS/MS method can be used to quantify differences in the magnitude of oil exposure across the observed field exposure levels in these mobile animals.

To evaluate the magnitude of PAH exposure relative to fish injury thresholds reported in the literature, we must understand the relationship between the results of the new LC-MS/MS method and the previous standard method that uses high performance liquid chromatography with fluorescence detection (HPLC-F). To compare methods, we analyzed 18 bile samples from wild-caught Red Snapper (Lutjanus campechanus) via both methods. Results indicate that the two methods correlate well ($r = 0.75$, $p < 0.001$); however, high outlier values may fall outside of the expected relationship, potentially as a result of the difference in what is detected and reported between methods.

These results support the use of LC-MS/MS to measure biliary PAH metabolites as a method of establishing exposure and injury to fish for NRDA at oil spills and other PAH-contaminated sites.

6.02.P-Th111 Uptake of Polycyclic Aromatic Hydrocarbons via High-Energy Water Accommodated Fraction (HEWAF) by Beach Hoppers (Amphipoda, Talitridae) Using Different Sandy Beach Exposure Pathways

Bryand Duke[1] (1)NOAA

Sandy beach ecosystems are highly dynamic coastal environments subject to a variety of anthropogenic pressures and impacts. Pollution from oil spills can damage beach ecosystems through the toxic effects of hydrocarbons on organisms and the disruptive nature of large-scale clean-up practices. On temperate sandy beaches, intertidal talitrid amphipods are primary consumers of macrophyte wrack subsidies and serve as prey for higher trophic level consumers, such as birds and fish. These integral organisms of the beach food web can

be exposed to hydrocarbons by direct contact with oiled sand through burrowing and by the consumption of oiled wrack. We used a novel method to experimentally evaluate the primary polycyclic aromatic hydrocarbon (PAH) exposure pathway via high-energy water accommodated fraction (HEWAF) for a species of talitrid amphipod (Megalorchestia pugettensis) in the laboratory. Our results indicated that tissue PAH concentrations in talitrids were six-fold higher in treatments that included oiled sand compared to those with only oiled kelp and the controls

6.02.P-Th112 Evaluation of Renewable Diesel Toxicity Using High-Energy Water Accommodated Fractions

Randi Barton[1], April DaSilva[2], Martice Vasquez[2], Cerasela Gadberry[2] and Bushra Khan[1] (1)University of California Davis (UC Davis), (2)California Department of Fish and Wildlife, Office of Spill Prevention and Response

California currently leads the United States in renewable diesel import and consumption, driven by the implementation of the Low Carbon Fuel Standards (LCFS) and associated rebate incentives. Pure renewable diesel is shipped from international sources to California, mixed with conventional diesel at coastal facilities, and shipped across the state for use. With increases in commercial use of renewable diesel in California, it is important to assess the ecological impacts of a potential spill. However, the effects of renewable diesel and renewable diesel blends on freshwater and marine environments remain largely unknown. To address these data gaps, we conducted standard toxicity testing with preparations of high-energy water accommodated fractions (HEWAF) of four fuel types. The HEWAF preparations included 100% renewable diesel (RND), 100% conventional diesel (CND), and two renewable diesel blends – 20% CND : 80% RND (Blend 1), and 5% CND : 95% RND (Blend 2). Toxicity testing was conducted with four model organisms - Atherinops affinis (a marine fish), Pimephales promelas (a freshwater fish), Mytilus galloprovincialis (a marine invertebrate), and Ceriodaphnia dubia (a freshwater invertebrate). Total petroleum hydrocarbons (TPH) and polycyclic aromatic hydrocarbons (PAHs) were measured in the HEWAF preparations and toxicity point estimates were calculated based on dose response curves generated from the HEWAF dilution series. Of the organisms tested, C. dubia was the most sensitive to renewable diesel HEWAF exposures. C. dubia was the only organism to show a dose response to HEWAF prepared with 100% RND (LC50 = 1.745 % HEWAF, EC50 = 0.241 % HEWAF) and both renewable diesel blends (Blend 1: LC50 = 0.5955 % HEWAF, EC50 = 0.1721 % HEWAF; Blend 2: LC50 = 0.5417 % HEWAF, EC50 = 0.1861 % HEWAF). No significant effects were noted in 100% RND HEWAF exposures with A. affinis, P. promelas, and M. galloprovincialis. Some qualitative behavioral effects related to fish feeding and swimming were noted in the toxicity tests conducted with the renewable diesel blends but need further investigation.

Man, Environment and Microbes—Unravelling the Contributions of the Unseen Workforce in Sustainable Pollution Management

6.05.T-02 Uncovering the Genetic Basis of Polyhalogenated Ethene Defluorination by Model Dechlorinating Microbial Consortium

Geneviève Haché[1], Amy Rand[1] and Daniel Grégoire[1] (1)Carleton University

Per- and polyfluoroalkyl substances (PFAS) are key targets for remediation due to their widespread contamination and environmental persistence. Among various strategies, microbial remediation has emerged as a promising avenue for PFAS remediation due to its sustainability, low cost and reduced environmental impact. Organochloride-degrading bacteria are a strong focus for PFAS bioremediation because of their ability to break carbon-chlorine bonds, which are analogous to carbon-fluorine bonds, although weaker. Recent work has shown that the commercial microbial consortium WBC-2 can break carbon-fluorine bonds in PFAS through reductive dehalogenation, though the mechanism remains poorly understood. To better understand the mechanisms responsible for defluorination, we will compare WBC-2's ability to dehalogenate trichloroethylene (TCE) – its preferred substrate – and two forms of fluorine-substituted TCE. We hypothesize that defluorination rates in fluorine-substituted TCEs will be encouraged by these compounds' similar size and shape to WBC-2's preferred substrate.

WBC-2 will be grown anaerobically in synthetic groundwater with essential vitamins (e.g., B12) and lactate as an electron donor. These cultures will be supplied with 220 μM of one of three substrates: TCE, 1,2-dichloro-1-fluoroethylene (single fluorination) or 1-chloro-1,2-difluoroethylene (double fluorination). The isomers of fluorine-substituted TCEs were chosen based on TCE's most likely sites of initial microbial dechlorination from previous literature. Sterile controls will account for abiotic reactions. Over eight weeks, aqueous samples will be collected by needle and analyzed using gas chromatography-flame ionization detector (GC-FID) to track consumption of the parent compounds and characterise products. Rates of dechlorination and defluorination will further be measured by detecting intra- and extracellular Cl- and F- levels with ion chromatography. In our next steps, these data will be paired with short-read metagenomic sequencing and RNA metatranscriptomic sequencing to gain insights on microbial community composition changes and available pathways, and to identify genes up- or downregulated in response to fluorine-substituted TCEs. These results will advance knowledge on anaerobic defluorination to ultimately inform strategies for PFAS bioremediation, helping to address a critical challenge in global pollution control and human health.

6.05.T-03 Microbial Influences on Plastic Degradation and Toxicity in Threespine Stickleback

Sarah Pasqualetti[1], Victoria Rosario[1], Jolie Atwood[1], Abiodun Aderibigbe[2], Jakiya Sultana Joya[2], Nataly Vargas[1], Sofia Vargas[1], Sihan Bu[1], Holly Valentine[1], Caroline Vieira Da Silva[1], Megan Teigen[1], Maria Lovallo[1], Devan Chancey[1] and Kat Milligan-McClellan[1] (1)University of Connecticut Department of Molecular and Cell Biology, (2)University of Connecticut Department of Chemistry

Polyethylene terephthalate (PET) and polypropylene (PP) are among the most widely produced plastics in the United States and often persist in cold-water environments where plastic-degrading microbes remain poorly characterized. Although Alaskan waters are contaminated with plastic, no cold-water plastic-degrading

microbes have been identified, and little is known about how gut-associated microbes contribute to in vivo plastic degradation in cold water systems. Understanding how gut microbes interact and contribute to plastic degradation is essential for developing potential microbiome-based bioremediation strategies. To address this gap, we screened 184 microbes isolated from wild Alaskan threespine stickleback (Gasterosteus aculeatus) guts samples from six bodies of water for plastic degrading potential using lipase/esterase assays and biofilm formation on PET and PP. Isolates with the highest activity were incubated in minimal media containing PET or PP as the sole carbon source to evaluate active plastic degradation. Surface analysis identified a Pseudomonas trivialis strain that degraded PP in monoculture. We next investigated whether microbial interactions influence plastic degradation. Some gut microbiota members enhanced and suppressed the lipase, esterase, and biofilm activity of other microbes. Co-inoculation experiments showed that PP degradation by P. trivialis is suppressed in the presence of another gut isolate, Pseudomonas germanica. These results show there is a cold-water fish gut microbe able to degrade plastic and that microbial interactions can inhibit this function. Ongoing work is testing mechanisms underlying this suppression, including resource competition, secreted inhibitory compounds, and transcriptional regulation of plastic-degrading enzymes. Future in vivo studies will evaluate whether P. trivialis mitigates the effects of nanoplastic exposure in larval threespine stickleback. Understanding these mechanisms will inform strategies to minimize inhibitory interactions and improve microbiome-based bioremediation approaches in plastic-contaminated cold-water environments.

6.05.T-04 Fungal-Based Biosorption: An Eco-Friendly Strategy for Heavy Metal Removal From Contaminated Water

Anjali Prajapati[1] (1)Swaminarayan University

Fungal-based adsorbents are gaining widespread attention as an eco-friendly and cost-effective solution for removing heavy metals (HMs), particularly in dilute solutions where synthetic resins are ineffective. The goal of this study was to develop a fungal biosorbent for the removal of HMs from wastewater. For this, Curvularia lunata, AD6 strain was isolated from a municipal solid waste and evaluated for its capacity to remove various HMs in non-competitive and competitive systems where the removal efficiency order was Cr > Pb > Cd > Ni > Cu in 2 h. The maximum metal removal capacity were ranged from 3.83 to 6.24 mg/g under optimized conditions. The role of various functional groups and surface chemistry of the fungal biosorbent was determined by FTIR and SEM. Furthermore, the thermodynamic parameters proved that the biosorption process was endothermic, spontaneous and feasible. The adsorption equilibrium isotherms and kinetic modelling studies were significant proven a multi stage physisorption and chemisorption. The biosorbent showed a significant removal of Ni and Cu when applied to the electroplating industrial effluent and metallic leachate in a laboratory scale up study. These findings indicated that the fungal sorbent AD6 possesses potential efficiency for the removal of various HMs from contaminated water.

Disclaimer/Disclosure: I am extremely thankful to Gujarat Government for SHODH Fellowship (ScHeme of Developing High Quality Research), Knowledge Consortium of Gujarat, Government Resolution No ૫૭૮/૨૦૧૯/૮.૫ા.૬૪૭/૫-૧, dated 05-08-2019 issued by Education Department, Student Ref No: 202001380120.

6.05.T-05 Soil Microbial Communities and Role of Indigenous Plants in Phytostabilization

of Cadmium, Lead, and Chromium at a Municipal Dumpsite, Southeastern Nigeria

Mary Iwuagwu[1], Onwuchekwa Ojimgba[1], Emmanuel Okafor[1] and Happiness Ezechukwu[1] (1)Abia State University, Uturu

In many developing countries, municipal dumpsites are major reservoirs of heavy metal contaminants such as cadmium (Cd), lead (Pb), and chromium (Cr). Contaminant mobility, ecological health, and human exposure risk associated with dumpsite environments are strongly influenced by plant-microbe interactions. This study evaluated Cd, Pb and Cr contamination in a municipal dumpsite ecosystem in Southeastern Nigeria and assessed the soil microbial community as well as phytostabilization ability of indigenous plants in reducing contaminant mobility. Soil and plant samples were collected from dumpsite and reference locations. Metal concentrations in the soil and roots, stems, and leaves of selected plant species including Asystasia gangetica, Centrosema pubescens, Andrographis paniculata, Emilia praetermissia, Sida acuta, and Aspilia africana were determined using atomic absorption spectrophotometry. Soil microbial communities were assessed as total heterotrophic bacteria count, total coliform count, total phosphate solubilizing bacteria count, total nitrifying bacteria count and total fungi count. Contamination factor (CF), pollution load index (PLI), bioaccumulation factor (BCF), and translocation factor (TF) were used to evaluate metal transfer and remediation potential. Dumpsite soils showed elevated concentrations of Cd, Pb, and Cr relative to the reference site. CF values revealed very high contamination for Cd (8.34) and considerable contamination for Pb (3.69) and Cr (5.63) while the PLI (5.58) confirmed severe multi-element pollution. Plant uptake patterns showed species-dependent differences in contaminant sequestration. A. gangetica exhibited the highest Cd accumulation (BCF = 1.50), whereas Pb and Cr accumulation were comparatively lower in all species (BCF < 1). TF values for Cd were generally below unity, indicating restricted shoot translocation and enhanced root sequestration consistent with phytostabilization mechanisms. In contrast, some species (C. pubescens, A. paniculata, and A. africana) showed moderate translocation of Pb and Cr, suggesting complementary phytoextraction potential. Microbial analyses revealed significant shifts in bacterial and fungal community structure, with selective enrichment of metal-tolerant populations in contaminated dumpsite soil compared to the reference site. These findings highlight the role of plant-microbe interactions as an integral component of natural phytostabilization processes in urban dumpsite soil.

Man, Environment and Microbes—Unravelling the Contributions of the Unseen Workforce in Sustainable Pollution Management

6.05.P-Th199 Petroleum Hydrocarbons-Induced Changes in Polluted Soil

Chidinma Peace Okafor[1] (1)Imo State University

Recently, the Niger Delta region of Nigeria has witnessed the proliferation of illegal make-shift refineries without proper regulations. To escape the watchful eyes of government, these refineries are usually located in very remote locations where they pose ecological disruptions of pristine environments. This work chronicled the impact of such refinery waste dumping site within its first six months of operations. It measured the changes in microbial counts, physicochemical parameters, and concentrations of heavy metals, nutrients, total petroleum hydrocarbons (TPH), polycyclic Aromatic hydrocarbons (PAHs) and Benzene, Toluene, Ethylbenzene, and Xylene (BTEX) in the polluted site. Sampling was done every 14 days and the samples aseptically transported to the laboratory for the various investigations. Results show that the initial levels of heavy metal investigated in

mg/kg of soil (Vanadium: 63.2, Nickel: 1.3, Lead: 3.6, Chromium: 1.23, Zinc: 5.34, Cadmium: 0.19, Iron: 134, Manganese: 22.3, Copper: 2.63 and Arsenic: <0.0001) were within regulatory standards. Initial soil pH was 4.3, became 3.9 by the 6th week and hovered around 3.9±0.1 for the duration of the study. Levels of PAH (18.30mg/kg) and Toluene (0.9620), Ethylbenzene (0.9334mg/kg), and Xylene (1.4402mg/kg) were within regulatory concentrations throughout the study period. However, TPH and Benzene concentrations; TPH (14,401,616mg/kg) and Benzene (6.3013mg/kg) of soil were very high from inception. Microbial count decreased from day 0 to day 28 and increased on day 42. Concentrations of nutrients in the soil depleted as the concentration of pollutants increased. Interestingly, the concentrations of Vanadium (468mg/kg), and Iron (560mg/kg) increased at the end of the six months study. This study shows the gradual disruption of soil factors and microbial activities through the effects of oil pollution. A combination of acidity, high benzene and TPH concentrations and spike in Vanadium concentrations is dangerous for the environment. However, indigenous microbial communities capable of tolerating these extreme conditions were found, hence could serve as major players in ecosystem restoration efforts of abandoned sites.

Disclaimer/Disclosure: This work was sponsored by the Tertiary Education Trust Fund(TETFUND) of the Federal Republic of Nigeria

6.05.P-Th200 Synergistic Bioremediation of Synthetic Acid Mine Drainage Utilizing Biochar-Alginate Immobilized Bacillus subtilis

Aadhrit Peram[1] (1)BASIS Chandler High School

Acid Mine Drainage (AMD) is a very severe environmental issue, characterized by extreme levels of acidity and high concentrations of toxic heavy metals. AMD creates biological dead zones across the world, with over 500,000 abandoned mines in the US contributing to its release. Current treatment methods often rely on costly and chemically intensive processes. To address this global environmental crisis, this study uses an integrated bioremediation system utilizing a date-palm biochar-alginate matrix for heavy metal adsorption and immobilized Bacillus subtilis for nitrate metabolism. Synthetic AMD (pH 3.5) was formulated using various chemical salts and subjected to four experimental conditions: an untreated negative control, biochar-only beads, biochar-bacteria composite beads, and a NaHCO3 pH control. To test the remediation efficiency, chemical analysis was primarily used; however, ecotoxicological reductions were tested using bioassays with Daphnia magna and Lemna minor

.

The system demonstrated very effective contaminant removal, eliminating 90% of copper (initial conc. 4.5 mg/L) and 80% of nitrates (initial conc. 18.4 mg/L) over a 5-day testing period. The treatment also reduced AMD toxicity to aquatic organisms and plants, supporting a 75% survival rate in D. magna and facilitating the only positive growth observed in L. minor. In conclusion, this immobilized matrix provides a highly effective and biocompatible solution to restore contaminated mine water in vitro. The system shows great promise in legacy mining environments by linking chemical removal with actual benefits for ecotoxicology.

6.05.P-Th203 Inoculation of Arbuscular Mycorrhizal Fungi and Organic Amendments on Lead Bioaccumulation in Maize (Zea mays L) Cultivated Adjacent to a Mining Site

Ikwuakonam George Okoro[1] (1)Michael Okpara University of Agriculture Umudike

Amagu Enyigba, is located in the Abakaliki Local Government Area of Ebonyi State, is renowned for its rich deposits of lead (galena) and zinc ores. Mining activities in this region have been ongoing for decades, and these activities have also led to substantial environmental degradation and agricultural depletion. Microbial inoculants have been scientifically proven to ameliorate contaminated soils, while biochar and poultry manure are known to provide a more conducive environment for microbial restoration in contaminated soil. Soil samples from the agricultural farms within the mining sites were collected, processed and transferred into a perforated bucket to which composted poultry manure (CPM) and biochar were applied at specific rates. The soil was moist for 2 weeks before arbuscular mycorrhizal fungi (AMF) were inoculated and maize seeds were planted. Lead concentrations were subsequently measured in soil, roots, and shoots after six weeks using standard analytical procedures.

The result showed a significant increase in the level of lead in the soil as CPM was applied. The amount of lead in the soil was observed to increase as the rates of biochar applied increased. The inoculation of AMF spores into the polluted soil generally increased the amount of lead. Soil inoculated with Rhizophagus intraradices and Clariodeoglomus etunicatum had a significantly higher ($P \leq 0.05$) increase (20.6 % and 14.6 %, respectively) in lead level in the soil than the control. The result further showed a significant increase in the level of Pb in maize roots as CPM was applied. Inoculation of AMF into the soil generally increased lead bioaccumulation in the shoot. Soil samples inoculated with Rhizophagus intraradices and Clariodeoglomus etunicatum had a higher increase in lead (79.2 and 83.8 mg/kg) accumulation in the shoot than the control (42.5 mg/kg).

These findings demonstrate that the combined application of organic amendments and AMF can increase heavy metal mobility and bioaccumulation in contaminated soils. Scientifically, these advances in understanding of rhizosphere processes by revealing the dual functional role of AMF in nutrient acquisition and heavy metal transport. From an applied perspective, the study highlights the need for awareness in using such amendments in polluted agricultural systems due to potential risks of heavy metal entry into the food chain. It also suggests potential application in phytoremediation strategies.

6.05.P-Th204 Linking Biosolid Legacy, Nitrogen Cycling, and Soil Properties to PFAS Biotransformation and Terminal PFAS Attenuation in Agricultural Soils

Sumantee Baidya[1], Wayne Omagamre[2] and Lena Link- grant[3] (1)University of Maryland Eastern Shore, (2)Univeristy of Maryland Eastern Shore, (3)University of Maryland Eastern Shore

Land application of biosolids is a major pathway through which per- and polyfluoroalkyl substances (PFAS) enter agricultural soils. While PFAS accumulation in biosolid-amended environments is well documented, the influence of long-term biosolid management on microbial processes governing PFAS fate remains poorly understood. Preliminary characterization of agricultural soils collected from Maryland farms with contrasting biosolid application histories revealed substantial differences in PFAS occurrence. Soils from a field receiving repeated biosolid applications over approximately 30 years contained higher PFAS concentrations and a broader suite of detectable compounds than soils from a field with a single biosolid application within the previous five years. Long-chain PFAS, including PFOS, PFDA, PFUnA, PFDoA, PFDS, and PFTeDA, were particularly enriched in historically amended soils, suggesting prolonged exposure histories that may influence microbial

adaptation and PFAS transformation potential.

This study investigates whether biosolid application history, soil type, and nitrification-associated microbial processes influence PFAS biotransformation and attenuation potential in agricultural soils. Aerobic soil microcosms are being established using representative IgB and HcA soils collected from fields with contrasting biosolid management histories and amended with the Wellington Laboratories MX-I PFAS mixture. Parallel treatments receiving the nitrification inhibitor 3,4-dimethylpyrazole phosphate (DMPP) are being used to evaluate the role of nitrogen-cycling processes in PFAS fate. Soil samples collected at the beginning and conclusion of a 60-day incubation are being analyzed to quantify changes in PFAS precursor composition, formation of terminal PFAS products, and changes in existing terminal PFAS concentrations. Soil physicochemical properties and nitrogen-cycling functional genes are also being quantified to characterize microbial responses associated with PFAS transformations. Results from PFAS, soil chemistry, and microbial analyses will be presented.

Man, Environment and Microbes—Unravelling the Contributions of the Unseen Workforce in Sustainable Pollution Management

6.05.V-01 Leveraging Microbes for SDG 14 Progress

Reshum Aurora[1] (1)Ashland High School

To promote sustainable use of marine resources, the United Nations Sustainable Development Goal 14 (SDG 14): Life Below Water aims to alleviate the impacts of marine pollution, habitat degradation, unsustainable fishing, and ocean acidification on ocean ecosystems. With the 2030 deadline approaching, much work remains, necessitating innovative solutions for mitigating chemical and biological stressors that affect ocean health. Here, we emphasize that microorganisms represent powerful, yet underutilized tools for contaminant transformation, excess nutrient removal, and food web enhancement that can be leveraged to advance SDG 14. We outline current microbial technologies, research needs, and deployment strategies to translate microbial applications into potential SDG 14 solutions. We also highlight the importance of protecting microbial biodiversity to preserve the ecosystem services that will maintain the outcomes of SDG 14. Integrating microorganisms into existing ocean management and policy frameworks represents a compelling pathway to accelerate progress towards global ocean sustainability.

6.05.V-02 Microbial Metagenomics of Hydrocarbon-Polluted Wetlands in Ogoniland

Chioma Chikere[1], Elizabeth Briggs[2] and Victor Ezebuiro[3] (1)1. Department of Microbiology, University of Port Harcourt; 2. Department of Environmental Sciences, University of South Africa (UNISA), (2)World Bank Africa Centre of Excellence in Oilfield Chemicals Research (ACE-CEFOR), University of Port Harcourt, PMB 5323 Choba Port Harcourt, Rivers State, (3)Regional Centre for Biotechnology and Bioresources Research, University of Port Harcourt, East-West Road, Choba, Port Harcourt, Rivers State

Petroleum contamination poses a major environmental challenge in the Niger Delta, affecting soil quality and microbial ecosystem functions. This study employed shotgun metagenomic sequencing to characterize bacterial communities in hydrocarbon-polluted (PS-1) and unpolluted (UPS-3) wetland soils from Gokana, Rivers State, Nigeria, and to assess their functional responses to petroleum contamination. Total petroleum hydrocarbons

(TPH) concentrations were 78.3 mg/kg in PS-1 (exceeding the 50 mg/kg regulatory limit) and 10.8 mg/kg in UPS-3. A total of 4.2 million high-quality reads were obtained across both samples, comprising 98.5% bacterial, 1.2% archaeal, and 0.3% fungal sequences. Sample PS-1 was dominated by hydrocarbon-degrading taxa, including Micrococcus (16%), Arthrobacter (12%), Gordonia (9%), Mycobacterium (8%), and Paenibacillus (6%). These taxa harboured catabolic genes such as alkB, CYP153, and PAH dioxygenases, accounting for approximately 14% of annotated functional genes and reflecting strong hydrocarbon degradation potential. In contrast, the unpolluted soil (UPS-3) was enriched with Extensimonas (11%), Comamonadaceae (9%), Bacteroides (8%), and Prevotella (6%), containing genes for carbohydrate-active enzymes (GH, GT, CE; 21%) and nitrogen cycling (nifH, amoA, nirK/nirS at 9% abundance). These outcomes demonstrated a functional shift from nutrient cycling in unpolluted soil to hydrocarbon catabolism in polluted soil, highlighting the adaptive resilience of indigenous microbial communities. The dominance of hydrocarbon-degrading taxa and associated genes in PS-1 underscores intrinsic bioattenuation potential, supporting monitored natural attenuation and biostimulation as viable remediation strategies for oil-impacted wetlands in the Niger Delta.

6.05.V-03 Impact of Hydrocarbon Pollution on Fungal Community Structure in Niger Delta Wetlands

Chioma Chikere[1], Elizabeth Briggs[2] and Victor Ezebuiro[3] (1)1. Department of Microbiology, University of Port Harcourt; 2. Department of Environmental Sciences, University of South Africa (UNISA), (2)World Bank Africa Centre of Excellence in Oilfield Chemicals Research (ACE-CEFOR), University of Port Harcourt, PMB 5323 Choba Port Harcourt, Rivers State, (3)Regional Centre for Biotechnology and Bioresources Research, University of Port Harcourt, East-West Road, Choba, Port Harcourt, Rivers State

Hydrocarbon contamination in Niger Delta wetlands poses a serious threat to soil microbial diversity and ecosystem stability. This study examined the effects of crude oil contamination on fungal community structure in hydrocarbon-polluted (PS-1) and unpolluted (UPS-3) wetland soils from Gokana, Rivers State, Nigeria, using shotgun metagenomics. Total petroleum hydrocarbons (TPH) were 78.3 mg/kg in PS-1 and 10.8 mg/kg in UPS-3. At the phylum level, Ascomycota dominated both soils, representing over 99 % relative abundance. In the unpolluted soil (UPS-3), the dominant classes were Sordariomycetes (~99 %) and Dothideomycetes (~1 %), whereas polluted soil (PS-1) exhibited a lower classification rate (18 % classified reads), indicating reduced diversity. At the order level, Botryosphaeriales, Microascales, and Hypocreales were most abundant in UPS-3, with the family Ophiocordycipitaceae representing approximately 80% relative abundance. Genus-level analysis identified Purpureocillium lilacinum (~85 %) as the dominant taxon in unpolluted soil. Whereas, polluted soil (PS-1) was dominated by Hypocreales, Eurotiales, and Sordariales, with Nectriaceae (65 %), Aspergillaceae (20 %), and Trichocomaceae (10 %) as the major families. At the genus level, Aspergillus (~45 %), Fusarium (~30 %), and Trichoderma (~15 %) were predominant, reflecting selective enrichment of hydrocarbon-tolerant and stress-resistant fungi capable of degrading crude oil contaminants. Diversity indices revealed significantly higher fungal diversity in UPS-3 (Shannon = 8.4; Simpson = 0.97) than in PS-1 (Shannon = 7.0; Simpson = 0.98). These findings demonstrated that hydrocarbon contamination reduced fungal diversity and selected hydrocarbon-tolerant taxa, underscoring the adaptive and bioremediation potential of indigenous fungal communities in Niger Delta wetland ecosystems.

Author Index

A

Abbatt, Jonathan 4.09.P-We067

Abdolahpur Monikh, Fazel 1.10.T-05

Abro, Tabish Latif 5.09.P-Tu286

Abu Khajil, Dania 1.02.P-We240

Abuelo, Angel 8.03.P-We010

Accolla, Chiara 4.03.T-06

Ackerly, Kerri 4.22.P-Th217, 5.17.P-We258

Ackerly, Kerri Lynn 2.01.P-Tu071

Acquah, Joseph 1.12.P-Tu226

Acuna, Shawn 2.10.P-We121, 5.16.P-We296, 7.10.P-Tu299

Adachi, Rina 4.22.P-Th226

Adamiano, Alessio 8.03.P-We003

Adams, Dexter 8.05.P-We217

Adams, Douglas 2.07.T-03

Adams, Julie 2.06.T-05

Adams, Kendra 4.19.T-03, 4.21.P-Th151

Adams, William 1.15.T-01

Adedeji, Adesola 5.10.P-We132

Adediji, Olusheyi L 1.07.P-We086

Adelmard, Valentin 2.01.P-Tu079

Adeola, Abdullahi 4.27.T-04

Adeoye, Gabriel 3.04.V-01

Aderibigbe, Abiodun 6.05.T-03

Adesanya, Adekunle 5.11.P-Tu162

Adjei, Jedidian 4.22.T-05

Admasu, Banchiamlak 2.01.T.A-03

Aeppli, Christoph 2.06.T-04

Afantitis, Antreas 5.02.T.A-05

Aghabararnejad, Milad 8.04.P-Tu015

Agnata, Andersson 4.04.P-Th087

Agosta, Kathleen 4.04.P-Th087

Agua, Alon 2.01.P-Tu071

Aguilar-Mora, Paula 5.14.P-Th198

Agunloye, Tosho 7.08.P-Tu136

Ahabchane, Houssame-Eddine 1.07.P-We085, 4.04.P-Th102

Ahad, Jason 2.06.P-Th117, 2.07.P-We049

Ahad, Jason M. E. 2.06.P-Th116

Aherne, Julian 2.01.V-02, 4.24.T-04

Ahmad, Fatima 4.10.P-Tu007

Ahmad, Raees 4.06.T-03, 4.21.T-04, 5.17.P-We261

Ahmad, Zainub 1.08.P-We169

Ahmed, Aya 1.08.P-We171

Ahmed, Fatima 5.10.P-We129, 5.10.P-We138

Ahmed, Mohamed 4.17.P-Tu237

Ahmed, Sayem 2.03.T-05

Ahn, Jongchun 5.09.P-Tu292

Ahn, Sungwoo 4.15.P-Tu191

Ahrens, Angelica 3.08.P-Th040

Ahuzi, Adaku 3.06.P-Tu106

Aisch, Lena 4.21.T-03

Ait-Salhi— Derridj, Nina 1.13.P-Tu037

Aitken, Conal 5.15.P-Tu171

Ajaero, Chukwuemeka 2.06.P-Th113

Ajemigbitse, Moses 6.03.P-Tu027

Akel, Mary 5.04.T-01

Akinseye, O. Roland 6.01.P-We082

Akinseye, Roland 2.08.P-Tu060

Akintobi, Oluwakemi 5.10.P-We132

AKOTO, Osei 4.23.P-Tu160

Akrache, Nabil 2.02.P-Th253

Aksenov, Alexander 4.02.P-Tu197

Akujobi, Campbell 6.03.P-Tu026

Al-Afyouni, Malik 2.13.P-Th242, 2.13.P-Th243

Alaimo, Christopher 4.10.T-05

Alam, Md Samrat 2.07.P-We049

Alanagh, Hamideh 1.14.T-02

Alava, Juan José 3.08.P-Th039

Albuquerque, Ruth 3.06.T-06

Aldershof, Saskia 5.15.P-Tu167

Alftrén, Per 1.10.T-04

Alipanopoulos, George 2.02.T-05, 4.13.T-01

Allamby, Quinn 2.02.P-Th263

Allan, Sarah 6.01.T-05, 6.01.T-06, 6.02.P-Th109, 6.02.P-Th110

Allen, Joe 4.10.T-02

Allen, Joseph 8.05.P-We216

Alli, Abdel 1.04.P-Th168

Allison, Michael 2.09.T-03, 2.09.T-04

Almuhtaram, Husein 4.08.P-We031

Alternatives to Chronic Fish Testing Working Group, HESI Global Next Generation EcoRisk Committee 1.09.T.A-01

Alvarez, David 4.17.P-Tu247

Álvarez-Martínez, Jose Manuel 4.23.P-Tu149

Alvarez-Pugliese, Christian 4.22.T-05

Amano, Atsuko 4.24.P-We236

Amano, Yuto 2.07.P-We052

Amarualik Sr., Peter 4.24.P-We228

Amato, Matthew 4.02.T-05

Ammann, Severin 1.02.T-06

Amoniyan, Oluwasegun 5.10.P-We131

Amor, Ben 8.01.T-04, 8.04.P-Tu017, 8.04.P-Tu019

Amrine, Tyler 1.09.T.A-03

Amyot, Marc 1.01.T-03, 1.07.P-We085, 2.01.P-Tu079, 2.01.T.B-02, 2.14.P-We188, 2.14.P-We191, 2.14.P-We192, 2.14.P-We193, 2.14.T-01, 3.08.T-01, 4.04.P-Th102, 4.26.T-05

An, Lihui 4.15.P-Tu182

An, Seojin 1.06.P-Th023

Anand, Shuchi 4.08.P-We030

Anandha Rao, Balaji 4.22.T-05

Anders, Eva 2.01.P-Tu083

Anderson, Berkley 4.23.P-Tu151

Anderson, Dominique 2.01.T.B-03, 3.07.T.A-06

Anderson, Jeffrey 2.09.T-04

Anderson, Jenna 2.05.T-04

Anderson, Kim 4.05.P-Th135, 4.05.P-Th141, 4.05.P-Th142, 4.05.P-Th145, 4.05.P-Th146, 4.10.T-03, 4.27.T-05, 7.03.T-01

Anderson, Morgan 2.09.P-Tu033, 6.03.P-Tu024

Anderson, Todd 2.08.P-Tu067, 4.06.P-Tu213, 4.07.P-Tu139

Andersson, Johan 1.10.T-04

Andrews, Robert 4.08.P-We031

Andrews, Stephanie 2.05.P-We039, 4.05.T-01, 4.22.P-Th225

ANGELIER, Frédéric 3.08.P-Th044

Angell, Maureen 2.06.P-Th118, 2.06.T-02, 3.07.T.B-01

Angstadt, Kory 4.15.T-03

Aniolek, Gregory 2.01.P-Tu092, 2.03.P-Th008, 3.08.P-Th052

Ankley, Gerald 1.06.P-Th026, 1.06.T-05

Ankley, Phillip 1.05.T-02, 1.06.P-Th026, 1.06.T-05, 4.19.P-We207

Annireddy, Akhila 4.22.P-Th237

Annis, Mandy 3.07.T.A-01, 3.08.T-06

Antczak, Philipp 1.06.P-Th027, 1.06.T-02, 1.06.T-03

Anthony, Bonner 3.04.P-We309

Anton, Jessica 4.07.T-02, 4.22.P-Th214

Antoniades, Dermot 2.01.T.B-02

Aoyama, Kako 2.07.P-We052

Apeti, Dennis 7.10.P-Tu300, 7.10.P-Tu302

Apigian, Kyle 1.14.T-05

Apparicio, Philippe 4.01.P-Th158

Appel, Aleah 4.04.T.B-01

Arblaster, Jennifer 3.08.P-Th034, 5.02.P-We268, 5.02.T.A-03, 5.02.T.B-02

Arbuckle, Tye E. 5.10.P-We128

Arenzon, Alexandre 2.03.P-Th011

Argeñal-Avendaño, Nicole 5.14.P-Th198

Argyridou, Anna 5.02.P-We268

Ariyarathna, Thivanka 2.07.P-We047

Arlos, Maricor 4.23.P-Tu148, 4.27.P-We301, 4.27.T-06

Armbruster, Dominic 4.09.T-05

Armitage, James 1.09.P-Tu122

Armitage, Kristyn 2.12.P-We187

Armstrong, Brandon 2.02.T-06

Arnie, Joshua 3.06.P-Tu112, 3.06.P-Tu113, 5.01.P-We064, 5.05.P-We014, 5.05.P-We016

Arnold, Jack 3.02.T-02

Arnold, Mariah 1.15.P-We198, 1.15.P-We203, 1.15.T-02

Arnold, William 2.13.T-01, 4.09.T-04, 4.22.P-Th227, 5.04.T-03, 5.04.T-05

Arnot, Jon A. 1.09.P-Tu127, 4.09.P-We072

Arnot, Jon 1.09.P-Tu122, 4.03.T-03, 4.04.P-Th086, 4.22.P-Th230, 5.01.P-We059, 5.01.P-We060, 5.01.T-04

Aronsson, Andreas 1.01.T-05, 2.02.P-Th276, 2.02.P-Th277

Arrandale, Victoria 4.01.T-06

Arredondo Navarro, Andrea 4.10.P-Tu003

Arregui, Marina 3.08.T-03

Arrigoni, Giorgio 1.10.T-05

Artavia, Allan 5.04.P-We252

Artelle, Kyle 2.07.P-We058

Arth, Peter 3.03.P-Tu043

Arunachalam, Saravanan 8.09.T-04

Arzayus, Felipe 3.06.P-Tu103, 7.10.P-Tu300, 7.10.P-Tu302

Asahara, Haruyasu 4.15.P-Tu189

Asche, Emily 3.02.P-We036

Asefa, Elsai Mati 5.01.P-We061, 8.03.P-We005

Åsheim, Eirik 3.07.V-01

Ashley-Martin, Jillian 5.10.P-We128

Ashworth, Kela 6.01.T-04

Asnicar, Davide 2.07.P-We046, 2.13.P-Th241

Asselin, Hugo 2.09.T-06

Astill, Toby 4.02.P-Tu200

Ataria, James 5.07.T-02

Ataria, Jamie 7.07.T-03

Athauda, Ishara 4.08.P-We030

Atkins, Jeff 4.17.P-Tu246

Atkinson, Kirk 1.09.P-Tu128

Atkinson, Kirk D. 4.13.P-Th125

Attar, Azka 4.10.P-Tu005

Atwood, Jolie 6.05.T-03

Au, Sarah 1.09.T.A-03

Audy, Ondrej 4.16.V-01

Augusiak, Jacqueline 1.09.T.B-05

Augustin, Meghana 4.12.P-Tu258

Aurora, Reshum 6.05.V-01

Austin, Tom 2.03.P-Th012

Avellan, Astrid 3.06.P-Tu108

AVELLAN, Astrid 3.06.P-Tu110

Awkerman, Jill 1.04.P-Th175

Aydin, Sukriye Celikkol 8.02.T-06

Ayotte, Pierre 3.08.T-01, 4.04.P-Th102

Azani, Rayane 8.02.P-We256

Azevedo Ivamoto, Ana Clara 2.10.P-We113

Azimi, Parham 4.10.T-02

B

Babineau, Sommerlyn 4.04.T.B-01

Babusci, Erica 6.01.P-We083

Bachand, Paxton 1.08.P-We166, 1.08.P-We167, 2.13.P-Th242, 2.13.P-Th243, 4.09.P-We076

Backe, Will 4.02.P-Tu202, 5.01.T-02

Baek, Hanbee 5.09.P-Tu297

Baettig, Camille 1.05.P-Th182, 1.06.P-Th026, 1.06.T-05, 4.19.P-We207, 7.03.T-05

Bai, Yichuan 5.16.P-We292

Baidya, Sumantee 4.22.P-Th236, 6.05.P-Th204

Bailey, Frank 2.02.P-Th266

baker, tracie 2.05.T-01, 5.14.T-04

Baker, Bridget 2.02.P-Th251, 3.08.P-Th040, 5.14.T-04

Baker, Ed 7.04.T-02

Baker, Josh 2.02.P-Th269, 5.16.P-We299

Baker, Lisa 5.05.P-We012

Baker, Michael 4.27.T-03

Baker, Tracie 2.02.P-Th251, 3.08.P-Th040, 5.02.T.A-06

Bakker, Frank 5.15.P-Tu167

Baldassin, Paula 3.07.T.A-05

Baldin, Samira Leila 1.04.P-Th171

Baldwin, Austin 2.05.T-03, 2.12.P-We182

Balistieri, Laurie S. 2.14.T-03

Ball, Suzanne 5.02.T.B-06

Ballantyne, Joann 4.19.P-We208

Balmer, Brian 1.15.T-03

Bamgbose, Ifeoluwa 1.12.P-Tu225

Banno, Arisa 4.22.P-Th226

Bao, Han 4.10.P-Tu002

Baranton, Matilde 3.01.P-Th032, 3.07.T.B-02

Baratange, Clément 2.07.P-We056, 2.07.T-02

Barbeau, Louis-Clément 6.03.P-Tu025

Barber, Timothy 4.04.T.A-03

Bare, Jennifer 4.18.P-Tu276

Barkach, John 2.02.P-Th273

Barr, Erin M. 2.13.P-Th246

Barrangou, Rodolphe 5.05.P-We012

Barrera, Mauricio 5.09.P-Tu293

Barrera-Calva, Enrique 3.06.P-Tu115

Barret, Maialen 8.02.T-03

Barrett, Glenn 3.01.P-Th028

Barrette, Ariane 3.08.T-01, 4.04.P-Th102

Barrick, Andrew 2.03.T-05, 4.15.P-Tu187, 4.15.P-Tu188, 7.05.P-We155

Barron, Leon 4.05.T-01

Barst, Benjamin 2.10.P-We107, 2.12.P-We187, 4.04.P-Th091, 4.04.P-Th092, 4.04.P-Th105, 4.04.T.A-04, 4.04.T.A-05, 4.04.T.A-06

Barst, Benjamin D. 2.14.P-We192, 4.04.P-Th107

Bartlett, Adrienne 2.05.T-04, 2.06.P-Th120, 2.10.P-We117

Bartlett, Chris 8.08.T-04

Barton, Randi 4.18.P-Tu267, 6.02.P-Th112

Barton-Maclaren, Tara 1.09.P-Tu121, 1.09.P-Tu122, 4.03.T-03

Bartoszek, Ian 3.02.T-02

Bassignani, Philip 4.02.P-Tu204

Basta, Nicholas 3.04.P-We306, 6.03.P-Tu022

Bastias, Alfonso 4.22.P-Th237

Bastos, Nathalia 4.05.P-Th131

Basu, Niladri 1.05.P-Th180, 1.05.P-Th183, 1.05.T-04, 1.05.T-05, 1.08.P-We168, 1.09.P-Tu120, 1.09.P-Tu123, 1.09.T.A-05, 1.09.T.A-06, 1.09.T.B-03, 2.02.P-Th257, 4.03.P-Th164, 4.05.P-Th137, 5.07.P-We165, 5.07.T-03, 7.08.P-Tu137, 8.08.P-Tu309, 8.08.T-02

Bates, Taylor 2.07.P-We051

Batt, Angela 8.05.P-We217

Baudiffier, Damien 7.04.T-03

Bauer, Luana 2.14.T-04

Baumann, Lisa 1.07.P-We088

Baustert, Sara 8.03.P-We010

Bautista, Vanessa 2.06.P-Th114, 2.06.T-03

Baxter, Elsa 4.15.P-Tu173

Baya, Anabelle 4.15.P-Tu184

Bayen, Stéphane 1.05.T-04, 4.01.P-Th158, 4.05.T-03, 4.17.P-Tu240, 4.23.P-Tu159, 4.24.T-06, 4.25.P-Th195

Bean, Tom 3.08.P-Th047

Beard, Dylan B. 4.04.P-Th089

Beard, Dylan 4.04.T.B-02

Beasley, Isabella 5.02.P-We287

Beasley, James 4.05.P-Th138

Beaton, Meagan 4.15.P-Tu181

BEAUGELIN-SEILLER, Karine 4.13.P-Th127

Beaulieu-Laliberté, Aurélie 2.06.P-Th116

Beblow, Jordan 2.09.T-04

Becaert, Emmanuelle 2.14.P-We197

Becanova, Jitka 3.02.P-We032, 4.05.T-06, 4.09.P-We069, 4.18.P-Tu275, 4.25.P-Th194

Bechu, Aude 4.07.T-04

Beck, Ben 2.03.T-05

Beckers, Liza-Marie 4.22.P-Th229

Beckert, Samantha 2.02.P-Th278

Beckford, Floyd 4.24.V-01

Beckingham, Barbara 4.15.P-Tu177, 4.17.T-01, 4.24.P-We233

Bedford, Louis-Philippe 2.14.P-We193

Bedrossiantz, Juliette 1.04.P-Th167

Beegan, Chris 1.01.T-02

Beeler-Marfisi, Janet 3.07.T.B-03

Behrens, Sebastian 4.22.P-Th227

Bejarano, Adriana C. 3.04.P-We305

Bekele, Asfaw 2.06.T-04

Beking, Michael 4.04.P-Th086

Bélanger, Martin 2.14.P-We193

Belik, Justine 3.03.P-Tu041

Bell, Meagan 1.02.T-02

Bellanger, Cécile 1.13.P-Tu037

Bellis, Delaney 1.06.P-Th024, 1.06.T-03, 3.06.P-Tu111, 4.13.P-Th128

Bellot, Pauline 3.01.P-Th032, 3.07.P-Tu055, 3.07.T.B-02, 3.08.P-Th044

Belzer, Esmee 4.02.T-03, 4.06.T-04

Belzile, Karine 4.01.T-01

Benavidez, Angelica 4.10.P-Tu003

Bencic, David 1.02.T-02, 2.10.P-We111, 2.10.P-We112

Benfey, Tillman 2.13.P-Th241

Benkstein, Kurt 4.15.T-02

Bennett, C. James 2.05.T-04

Bennett, C.James 5.02.P-We280

Bennett, Melissa 4.23.P-Tu148

Bennett, Steven 8.08.T-02

Benoit, Francesca 4.01.T-01

Benson, Claire 3.08.P-Th052

Beqiraj, Sajmir 2.13.T-06

Berger, Phillip 4.17.P-Tu244

Bergeron, Normand 2.01.P-Tu083

Berglund Fick, Jerker 5.01.T-01

Bergman, Nathan 7.10.P-Tu301

Berthiaume, Alicia 4.18.P-Tu283, 4.22.P-Th230

Berthod, Camille 2.05.T-05

Bertoli, Jessica 1.02.T-06, 7.08.P-Tu135

Berubé, Sarah 4.04.T.B-06

Bérubé, Sarah 4.18.P-Tu279

Bessissow, Talat 1.08.P-We168

Best, Lauren 2.04.T-01

Beteille, Arthur 8.01.T-01

Bhaiyat, Sharmin 4.13.P-Th125

Bharadwaj, Anuja 5.17.P-We261

Biales, Adam 1.02.T-02, 2.10.P-We111, 2.10.P-We112

Bialik, Robert 4.04.T.A-03

Bidleman, Terry 4.04.P-Th087

Bidleman, Terry F. 4.04.T.A-02, 4.16.T-01

Bidwell, Mark 3.07.T.B-01

Bielmyer-Fraser, Gretchen 2.07.P-We051

Biggerstaff, Dan 4.02.P-Tu204

Bilkovic, Donna 4.15.T-03

Bilodeau, François 4.26.T-05

Bilodeau, Julie 2.06.P-Th118

Bimpong, Donald 4.24.T-06

Binning, Sandra 3.07.V-01

Binz, Christian 7.08.P-Tu135

Biot-Pelletier, Damien 1.05.P-Th185

Birsan, Alex 4.01.P-Th163, 4.02.P-Tu201, 4.07.P-Tu145, 4.19.P-We208, 4.21.P-Th154

Bisesi, Joseph 1.04.P-Th174, 2.01.P-Tu092, 2.05.P-We041, 2.05.P-We042, 2.05.T-01, 4.06.P-Tu217

Bishop, Christine 3.07.P-Tu051

Bisson, Isabelle-Anne 5.07.P-We165, 5.07.T-03

Bito, Tatsuya 4.17.P-Tu235

Blackman, Lauren 2.05.T-01, 3.02.P-We038, 4.06.P-Tu217

Blackshire, La Cole 7.05.P-We156

Blair, David 4.04.P-Th101

Blair, Stevie-Rae 7.07.T-03

Blais, Erica 1.09.P-Tu125, 5.10.P-We128

Blais, Jules 2.06.T-05, 6.01.P-We082

Blake, Johanna M. 1.15.P-We200

Blanc, Ariel 2.05.P-We043

Blanchard, Darian 4.23.T-03

Blanksma, Chad 1.06.P-Th026, 1.06.T-05

Blazer, Vicki 1.15.T-03

Blázquez, Mercedes 1.04.P-Th167

Blévin, Pierre 3.08.T-03

Blewett, Tamzin 2.04.P-Tu102, 2.04.T-04, 2.04.T-06, 2.10.P-We115, 3.07.V-01, 4.04.P-Th088, 4.04.P-Th089, 4.04.T.B-02

Blickley, Twyla 2.03.P-Th014, 5.11.P-Tu162, 5.11.P-Tu164

Blokland, Emily 4.18.P-Tu271

Blunt, Warren 4.09.P-We070

Bo Bo Aung, Phyo 4.15.P-Tu189

BOADI, Nathaniel 4.23.P-Tu160

Boatman, Anna 4.01.T-02

Bodman, Michael 2.05.P-We043

Bogantes Montero, Jorge 7.02.P-Th206

Bogialli, Sara 1.10.T-05

Bohannon, Meredith 1.09.T.A-02

Boisseaux, Paul 4.22.P-Th225

Bollinger, Eric 2.01.P-Tu089

Bond, Matthew 2.03.P-Th015

Bonfleur, Maria Lucia 2.06.T-03

Bong, Daehan 2.07.P-We047

Boni-Kazantzidou, Nefeli 4.21.T-01

Bonnell, Mark 4.04.P-Th086

Bonner, Emily 4.05.P-Th146

Bonnet, Matthieu 2.01.P-Tu068

Booth, Stephen 5.10.P-We142

Bordaz, Audrey 2.07.P-We056

Bordin, Luis 2.10.P-We098, 4.12.P-Tu256, 4.18.P-Tu263

Borg, Bridget 4.04.P-Th105

Borgert, Christopher 7.12.T-05

Borges, Shannon 5.05.P-We011

Borsa, Julie 2.02.P-Th258, 2.13.T-05, 5.04.P-We253

Bose, Rebecca 1.09.P-Tu121

Böserle Hudcová, Barbora 5.10.P-We153

Bossi, Rossana 3.08.T-03

Bottoms, Melanie 5.15.P-Tu169

Bouazza, Abdelmalek 1.12.P-Tu226

Boucher, Jean-Francois 8.09.T-03

Bouffard, Alexandre Bouffard 8.01.T-06

Bouhkari, Rania 1.01.T-03

Boulangé-Lecomte, Céline 2.01.P-Tu068

Boulanger, Emily 1.05.T-04, 1.05.T-06, 1.09.T.A-05

Boulay, Anne-Marie 8.01.T-01

Bouldin, Jennifer 4.02.P-Tu207, 6.03.P-Tu029

Bourque, Lyla 2.06.P-Th114, 2.06.T-03

Bouzane, Brenda 2.09.T-03

Bouzas Monroy, Alejandra 1.09.T.B-02

Bowden, John 1.04.P-Th174, 2.01.P-Tu092, 2.05.T-01, 2.07.T-03, 2.07.T-04, 3.02.P-We038, 3.02.T-02, 4.02.T-03, 4.06.P-Tu217, 4.06.T-04, 5.02.P-We275

Bowerman, William 7.04.T-06

Bowling, Bronte 3.01.T-03

Boyd, Bentley 2.01.P-Tu092

Boyd, Patrick 1.14.P-Tu227

Boynton, Lin 7.07.T-02, 7.10.P-Tu301

Boyte, Vann 1.03.T-01, 1.03.T-04, 1.03.T-05, 1.03.T-06, 1.09.P-Tu119, 1.13.T-06

Bozinovic, Goran 4.05.P-Th136, 4.26.P-Th284

Braaker, Sonja 5.15.P-Tu168

Brackett, Roxanne 2.07.P-We045, 5.05.P-We013

Bradford, Barry 8.03.P-We010

Bradley, Paul 4.08.P-We029

Brady, Sydney 4.07.P-Tu140

Bragg, Leslie 2.01.P-Tu085, 2.02.P-Th261, 2.10.P-We099, 4.22.P-Th215, 4.22.P-Th216, 5.17.P-We262, 5.17.P-We263

Brahmstedt, Evie S. 4.23.P-Tu150

Bramer, Lisa 4.05.P-Th146, 4.10.T-03

Branche, Tonia N. 5.04.T-01

Brander, Susanne 1.12.P-Tu221, 4.24.P-We235

Brandt, Elizabeth 3.01.P-Th031

Brandt, Jess 1.15.T-03

Branfireun, Brian 2.12.P-We183

Brar, Satinder Kaur 4.15.P-Tu185

Brauer, Liana 1.09.P-Tu126

Brauner, Colin 2.08.P-Tu062

Breitenstein, Martin 2.01.P-Tu088

Breivik, Knut 4.04.P-Th086

Brejnik, Jillian 4.09.P-We078

Brenes-Alfaro, Laura 5.14.P-Th198

Brennan, Jennifer 1.03.T-03, 1.09.T.A-03

Brereton, Nicholas 3.06.T-04

Bressette, James 1.09.T.A-03

Brettell, Nathan 5.11.P-Tu164

Brewer, Shannon 4.15.P-Tu188

Brewster, Christina 2.06.P-Th115

Briand, Timothée 4.22.P-Th221

Brice, Camille 2.10.P-We115, 4.04.P-Th088, 4.04.T.A-01

Briggs, Elizabeth 6.05.V-02, 6.05.V-03

Brindley, Stephen 1.04.P-Th168

Brinkmann, Markus 1.10.P-We303, 2.01.T.B-01, 2.02.P-Th252, 2.02.P-Th258, 2.02.T-06, 2.06.P-Th119, 2.13.T-05, 3.08.P-Th035, 3.08.P-Th053, 5.01.T-03

Brinovcar, Cassandra 4.16.T-04, 4.19.T-05, 5.02.P-We280, 5.02.T.B-01

BRISCHOUX, François 3.08.P-Th044

Brix, Kevin 1.15.P-We198

Broadbent, Jordyn 2.01.P-Tu069, 2.05.P-We040, 2.06.P-Th113, 2.06.P-Th120

Brodeur, Julie C. 3.01.P-Th029, 4.11.P-We161

Brodin, Tomas 3.07.T.A-06, 5.01.T-01

Brody, Charlotte 8.08.T-02

Brouwer, Gillian 8.02.P-We256

Brovini, Emília Marques 4.11.P-We162

Brown, Alistair 4.09.P-We070

Brown, Heather 1.06.P-Th026, 1.06.T-05, 1.10.T-02, 4.19.P-We207

Brown, Lisa 2.05.T-02

Brown, R Stephen 8.02.T-05

Brown, Rebecca 1.10.T-01, 1.13.P-Tu036, 1.13.P-Tu039

Brown, Ross 4.21.T-01

Brown, Stephen 8.02.P-We256, 8.02.T-01

Brown, Tanya 3.08.P-Th041, 4.17.T-03, 4.23.P-Tu153

Brown, Tanya M. 2.07.P-We050, 2.13.P-Th238

Brown, Trevor 5.01.T-04

Brown, Trevor N. 1.09.P-Tu127, 4.09.P-We072

Browne, Anson 5.01.P-We064

Brua, Robert B 2.06.P-Th113

Brua, Robert 2.06.P-Th120

Brühl, Carsten 2.01.P-Tu089

Brummer, Russell 5.02.P-We285

Brunelle, Laura 8.05.P-We217

Brunelli, Andrea 8.03.T-02

Brunet, Christopher 4.21.T-05, 4.22.T-03

Bruns, Eric 3.06.T-06

Brustolin, Roger 2.03.P-Th011

Brydon-Brown, Liam 5.06.T-02

Bu, Sihan 6.05.T-03

Bub, Sascha 2.01.P-Tu090

Buchman, Leah 5.05.P-We012

Bucking, Carol 2.02.T-02

BUDZINSKI, Hélène 3.08.P-Th044

Buell, Mary-Claire 2.12.P-We183, 4.24.T-04

Bueno, Carlos 4.25.T-01

Bullen, Jay 1.01.T-04

Bundschuh, Mirco 2.01.P-Tu089

Bunge, Michael 4.24.P-We230

Bunker, Paul 2.06.P-Th115

Buonocore, Jonathan 8.09.T-04

Burden, Natalie 1.13.T-02

Bürger, Leonhard 5.15.P-Tu166

Burke, Robert 3.02.T-06

Burnham, Jennifer 4.04.P-Th098

Burnham, Kurt 4.04.P-Th090, 4.04.P-Th098, 4.04.T.B-01

Burris, Janet 1.09.T.A-03

Burton, Erika 2.05.T-04, 5.02.P-We280

Bury, Nicolas 1.03.T-04

Busch, Wibke 4.22.P-Th229

Buser, Andreas 4.04.P-Th086

Bush, Kendra 1.05.P-Th181, 1.05.T-02, 1.05.T-03

Bussen, Dino 2.01.P-Tu090

Bussy, Anne-Laure 4.18.P-Tu269

Butler-Dawson, Jaime 1.04.P-Th168

Butt, Craig 4.21.P-Th151, 4.25.T-01

C

C. Quevedo, Ana 1.14.T-06, 2.03.P-Th007

C.O. Ferrari, Maud 2.10.P-We110

C.Quevedo, Ana 4.15.T-06

Cabezas, Sonia 3.07.T.A-03, 3.08.P-Th053

Cabezas Ruiz, Sonia 4.23.T-01

Cable, Rachel 4.24.T-05

Cabrera, Mia 4.23.P-Tu161

Cabrerizo-Pastor, Ana 4.04.P-Th091

Caceido, Joselyne 1.04.P-Th167, 1.13.P-Tu038

Cadmus, Pete 2.01.T.A-05

Cadonic, Ivan 3.07.V-01

Caicedo García, Joselyne Katherine 1.04.P-Th166

Calahorro-Nunez, Fernando 1.03.T-04

CALAS, Aude 3.06.P-Tu110

Calder, Hannah 4.15.P-Tu182

Caldwell, Catherine 8.02.T-04

Calisi, Antonio 5.02.T.A-05

Callahan, Damien 1.12.P-Tu226

Camara, Tidiane 2.14.P-We189

Cameron, Matthew 4.04.P-Th105

Camm, Eric 4.27.T-06

Campana, David 5.18.P-We021, 5.18.P-We022

Campbell, Barbara 2.01.P-Tu092

Campbell, Grace 8.08.T-04

Campbell, Kate 2.04.T-05

Campbell, Linda 2.02.P-Th260, 2.02.P-Th268, 3.02.P-We035, 4.13.T-06, 6.03.P-Tu023

Campbell, Linda M. 2.01.T-05

Campioni, Letizia 1.03.P-Th019

Campos, Bruno 1.05.T-05, 1.09.T.B-02, 5.09.T-02

Cancelli, Alexander 2.06.T-04

Candaudap, Frédéric 3.06.T-05

Candrl, James 1.06.T-01, 4.17.P-Tu247

Canfield, Timothy 7.12.T-01

Canoba, Analia 4.13.P-Th127

Cantin, Ariane 4.04.T.A-05

Capiaux, Hervé 2.07.P-We056

Caplette, Mariane 2.05.T-05

Cappelini, Luciana 4.06.P-Tu218

Capps, Tony R. 1.08.P-We166

Caprile, Ana Clara 3.01.P-Th029, 4.11.P-We161

Carazo-Rojas, Elizabeth 5.14.P-Th198

Cardenas, Diana 2.10.P-We099, 5.17.P-We262, 5.17.P-We263

Cardenas Campo, Juan Camilo 7.07.T-02

Cardinal, Sébastien 2.03.P-Th004

Carilli, Jessica 4.05.P-Th139, 6.03.P-Tu027, 6.03.P-Tu028

Carl, Rayna 2.01.T.B-01

Carle, Alice 2.14.P-We191

Carlos da Silva, Francisco 2.10.P-We110, 5.04.P-We253

Carlson, Trevor 2.02.T-06

Carmack-Smith, Cheryl 7.02.T-03

Carmo de Oliveira, Bruna 3.07.T.A-05

Carmona-Escalante, Armando 7.05.P-We157

Carneiro, Gabriel Reis Alves 4.11.P-We162

Carney, Randy 1.07.P-We090

Caron-Beaudoin, Élyse 1.02.P-We241

Carrasco Navarro, Victor 2.02.P-Th249

Carrierè, Kailey 2.08.P-Tu060

Carroll, John 1.06.T-01, 2.05.T-02

Carroll, Macon 1.08.P-We171

Carson, Carolee 8.02.T-06

Cartwright, Lyndsay 3.06.T-02

Carvalho, Paulo 1.06.P-Th022

Carvalho Rodrigues, Cândido 2.14.P-We192

Cary, Ethan 4.04.T.B-01

Casciano, Grace 1.05.P-Th182, 1.06.P-Th026, 1.06.T-05

Casey, Ryan 4.06.P-Tu216

Castillo, Nicholas 3.06.P-Tu103, 7.10.P-Tu300

CASTILLO-MICHEL, Hiram 3.06.P-Tu110

Castro-García, César 4.07.V-01

Castro-Gutiérrez, Víctor 5.14.P-Th198

Catalano, Shadia 5.10.P-We145

Catron, Tara 5.11.P-Tu165

Cavallin, Jenna 1.05.P-Th181, 1.05.P-Th182, 1.05.T-02, 1.05.T-03, 1.06.P-Th026, 1.06.T-05, 4.19.P-We207

Cavanaugh, Mary 4.21.T-02

Cavaneau, Emma 5.02.T.A-06

Celmer-Repin, Dominika 4.22.P-Th215

Centeno, Angela 1.13.P-Tu038

Cera, Alessandra 4.24.P-We226

Cerrato, Jose 4.10.P-Tu003

Cerveny, Daniel 5.01.T-01

CHABOD, Flavien 8.09.T-03

Chadwick, Jessica 1.14.T-02

Chalifoux, Alexandre 4.18.P-Tu266

Challis, Jonathan 4.22.P-Th234, 4.23.P-Tu147, 4.25.P-Th191

Champagne Saint-Arnaud, Valériane 8.09.P-Tu312

Chan, Diana 2.07.P-We058

Chancey, Devan 6.05.T-03

Chand, Preetika 3.06.V-01

Chand, Priyankar 2.07.P-We047, 4.06.T-03

Chandler, Andrea 2.01.P-Tu091

Chandra, Rashmi 6.01.T-04

Chandramouli, Bharat 4.01.P-Th160, 4.05.T-04, 4.22.P-Th231

Chandrapalan, Theanuga 1.04.P-Th169, 2.02.T-01

Chandrashekar, Akshaya 3.07.T.B-03

Chang, Mike 4.06.P-Tu214, 4.15.P-Tu182

Chang, Wonjae 6.03.P-Tu030

Chapman, Brennan 8.02.T-06

Chapman, Ellen 2.02.P-Th268, 6.03.P-Tu023

Chapman, Emily 2.01.T-05, 2.02.P-Th260

Chapman, William 2.01.T.B-02

Chará-Serna, Ana 2.08.P-Tu062

Charbonneau, Léo 4.02.T-01

Charbonnet, Joseph 4.22.T-01, 4.27.T-04, 5.02.P-We285

Charriere, Camryn 2.06.P-Th119

Chartrand, Tammy 4.02.P-Tu199, 4.06.P-Tu211, 5.02.P-We271

Chatfield, Matthew 3.02.P-We032

Chaumot, Arnaud 2.01.P-Tu068

CHAZEAUBENY, Alexis 3.08.P-Th044

Chedid, Carole 1.04.P-Th166

Chen, Chaobao 2.10.P-We109

Chen, Chengkang 4.24.P-We225, 4.24.T-01, 5.01.P-We063

Chen, Hui Qun 1.05.P-Th178

Chen, Maohui 4.15.P-Tu190

Chen, Wanzhen 4.08.P-We031

Chen, Wei-Yu 2.01.P-Tu077

Chen, Yanan 3.07.P-Tu045

Chen, Yingjia 4.17.P-Tu231

Chen, Yinjuan 5.09.V-01

Chen, Zhan 4.24.T-05

Cheng, Zhen 4.18.P-Tu283

Cheng, Zhipeng 1.13.P-Tu040, 4.07.T-05, 4.09.P-We067

Chepaitis, Patrick 4.10.P-Tu007

Chernick, Melissa 2.01.P-Tu080

Cheshire, Kelly 4.02.P-Tu204

Chet, Muny 2.02.P-Th266

Chetelat, John 2.06.T-02

Chételat, John 4.04.P-Th091, 4.04.P-Th107, 4.04.T.A-04, 4.04.T.A-05

Chi, Zhi Hao 4.23.P-Tu159, 4.24.T-06, 4.25.P-Th195

Chiblow, Susan 5.07.T-01

CHIDI, NOSIRI 5.10.P-We151

Chikere, Chioma 6.05.V-02, 6.05.V-03

Chikere, Hilary Chizaram 4.18.V-01

Chikere, Prof. Chioma Blaise 4.18.V-01

Chinthaka, S.D.M 2.01.P-Tu076

Chinthaka, S.D.M. 7.10.P-Tu299

Chisamore, Jared 4.01.T-04

Chiu, Suzanne 1.02.P-We240

Chivers, Douglas 1.15.T-04

Cho, Tae Joon 4.15.T-02

Choi, Hayeon 1.07.P-We096

Choi, Hoon 4.01.P-Th161

Choi, Hosik 5.06.P-We238

Choi, Jessica 4.24.T-05

Choi, Kyungho 1.10.P-We302, 5.09.P-Tu292

Choondal, Akhila Thomas 6.03.P-Tu030

Choquecota Riva, Alberto 5.09.V-01

Choy, Emily 3.01.T-02, 3.01.T-05, 3.01.T-06, 3.07.T.A-02, 3.08.P-Th045

Christensen, Jennie 1.15.T-03, 2.13.P-Th239, 3.07.P-Tu053, 4.03.T-04, 4.18.P-Tu261, 4.18.P-Tu262

Christenson, Mallory 2.02.P-Th252, 4.24.T-04

Christie, Diana 3.07.T.B-01

Chu, Shaogang 1.02.P-We243, 4.04.P-Th101

Chui, Ryan 1.05.T-04, 1.05.T-06

Chumchal, Matt 4.04.T.B-01

Chumchal, Matthew 4.04.P-Th090, 4.04.P-Th098

Chung, Katy 4.23.P-Tu156, 5.02.P-We276, 5.02.P-We277, 5.02.T.A-02

Churchman, Jacob 5.02.P-We274

Ciborowski, Jan J.H. 2.06.P-Th119

Cierjacks, Arne 2.13.T-06

Cioffi, Isabella 5.02.P-We275

Clapp, Phillip 1.08.P-We172

Clarisse, Olivier 4.13.T-04

Clark, Alison 4.05.P-Th135, 4.05.P-Th145, 4.05.P-Th146

Clark, Nathan 7.05.P-We160

Claude, Emmanuelle 4.19.P-We208

Claunch, Rachel 1.06.T-01

Clements, William 2.01.T.A-05

Cleveland, Mark 2.09.T-04

Clouthier, Jessica 4.25.T-05

Cloutier, Anne-Sophie 4.04.P-Th103

Coady, Katherine 1.13.T-03, 1.13.T-05

Cochran, Samuel J. 1.08.P-We172

Cochrane, Paige 2.07.T-01

Codling, Garry 4.21.T-01

Coelho, Carla 5.16.P-We297

Coelho, João Pedro 2.07.P-We056

Coffield, Olivia 5.02.P-We279

Cognie, Bruno 2.07.P-We056, 2.07.T-02

Cohen, Risa 2.02.P-Th248, 2.05.T-02

Colafranceschi, Julianna 3.01.T-02, 3.07.T.A-02

Colborne, Scott 7.04.T-02

Colbourne, Katerina 3.07.P-Tu048

Colby, Jordan 3.08.P-Th051

Cole, Alexander 7.03.T-05, 7.08.P-Tu136

Coler, Elizabeth 4.02.P-Tu197

Collier, Gracen 5.02.P-We269

Collier, Tracy 6.02.P-Th110

Collins, Cameron 1.03.T-04, 1.03.T-05, 1.03.T-06, 1.13.T-06

Collins, Cassandra 3.06.T-02, 3.06.T-03

Collins, Ian 5.09.P-Tu290

Collins, Jennifer 1.09.T.A-04

Collins, John 6.03.P-Tu027

Collis, Rose 8.01.T-03

Colussi, Alessia 4.25.T-03

Colvin, Kat 1.13.P-Tu039

Colvin, Molly 5.02.P-We284, 5.02.T.A-01, 5.02.T.A-03, 5.02.T.B-02, 6.03.P-Tu027

Comerford, Nicolas 3.07.T.B-01

Committee, Fisheries Joint Management 3.07.P-Tu048

Committee, Tuktoyaktuk Hunters and Trappers 3.07.P-Tu048

Comte, Jérôme 2.06.P-Th116

Conan, Andrew 2.06.P-Th113

Conder, Jason 3.08.P-Th034, 4.05.P-Th129, 4.05.T-05, 5.02.P-We268, 5.02.P-We272, 5.02.P-We281, 5.02.P-We284, 5.02.T.A-01, 5.02.T.A-03, 5.02.T.B-02

Conkin, John 3.07.T.B-01

Conkle, Jeremy 4.02.T-05, 4.05.T-06

Conklin, Jesse 5.01.T-02

Connell, Jodi 8.08.T-02

Connell, Mackenzie 2.02.P-Th251, 2.05.T-01, 5.02.T.A-06

Connolly, Jennifer 5.08.P-Tu130

Conto, John 2.03.T-03

Conway, Carla 1.06.T-04

Cook, Ellee 1.12.P-Tu223

Cook, Nonnie 1.03.T-05

Cook, Sarah Elizabeth 1.07.P-We086

Cooke, Colin A. 2.06.T-02

Cooke, Colin 1.15.P-We206, 2.06.T-01

Cookson, Adrian 8.01.T-03

Copenace, Jyles 6.03.P-Tu024

Copley, Tanya 4.23.P-Tu152

Corcoran, Patricia 2.01.V-02, 4.16.T-03

Cormet-Boyaka, Estelle 1.08.P-We172

Cornea, Anastasia 4.23.T-01

Cornelissen, Silke 4.04.P-Th106

Cornelius, Connor 5.03.P-We213

Cornelius Ruhs, Emily 5.07.T-04

Cornwell, Riley 3.07.T.A-01

Corp, Amy 2.05.P-We043

Corriveau, David 4.15.P-Tu190

Cortes-Lopez, Alejandra 2.01.P-Tu095

Costa, Maria 1.13.P-Tu038

Costantini, Sarah 2.07.T-01

Côté, Sébastien 4.01.T-01, 4.02.P-Tu193

Cottrell, Paul 3.08.P-Th039

Couillard, Julie 2.09.T-02, 2.09.T-05

Coulaud, Romain 2.01.P-Tu068

Coulombe, Stéphanie 4.04.P-Th103

Courville-Todorov, Mia 4.13.T-04

Couture, Emilie 3.07.P-Tu048

Couture, Patrice 1.01.T-03, 2.01.P-Tu083, 2.02.P-Th253, 2.14.P-We195, 4.14.P-We179

Couture, Raoul-Marie 2.14.P-We189

Covell, Lindsey 5.16.P-We295

Covert, Brenden 4.12.P-Tu257

Cowger, Win 4.17.T-01

Crago, Jordan 2.08.P-Tu067

Craig, Mark 1.01.T-04

Crane, Marin 2.09.P-Tu032

Cranney, Matthew 5.17.P-We264

Crawford, Eric 2.05.P-We043

Crawford, Sarah 4.23.T-03

Crawford, Titus 4.04.P-Th098, 4.04.T.B-01

Cremazy, Anne 1.01.T-03, 2.04.P-Tu102, 2.04.T-04, 2.04.T-06, 2.10.P-We115, 2.10.P-We116, 4.04.T.B-02, 4.13.P-Th122, 4.13.P-Th124

Crémazy, Anne 2.14.P-We194, 2.14.P-We195, 4.04.P-Th088, 4.04.P-Th089, 4.23.P-Tu155

Crescent, Summer 3.06.P-Tu103

Crimmins, Bernard 3.07.P-Tu045

Cristina Borges, Maria 2.10.P-We104

Cristina Caires Queiroga, Ana 3.07.T.A-05

Cristos, Diego 4.11.P-We161

Critchell, Kay 3.08.P-Th037

Croteau, Kelly 5.02.P-We289

Crouch, Carter 3.07.T.B-01

Crump, Doug 1.02.P-We240, 1.09.P-Tu120, 1.09.T.A-05, 1.09.T.B-01, 2.06.P-Th118, 3.01.P-Th028, 3.01.P-Th030

Crumpton, William 4.27.T-04

Cuchimaque, Carolina 4.06.P-Tu218

Cui, Weicheng 5.09.V-01

Culotta, Gemma 1.09.P-Tu120

Cunningham, Curry 2.10.P-We107

Cunningham, Jessie 5.02.T.B-01

Currie, Cameron 5.04.P-We252

Curtis, Amanda 3.07.T.A-01

Curtis-Jackson, Pippa 5.01.T-04

Custer, Christine 6.01.T-02

Custer, Thomas 6.01.T-02

Cutting, Kyle 4.15.P-Tu188

Cyril, Eva 5.04.P-We251

D

D'Camp, Roberta 6.03.P-Tu025

da Silva, Denis 4.17.P-Tu246, 6.02.P-Th110

da Silva, Francisco 2.02.T-06

Da Silva, Francisco 2.02.P-Th258

Da Silva, Judy 2.12.P-We184

da Silva Junior, Francisco Carlos 1.04.P-Th171

Dada, Oluwabunmi 5.09.P-Tu291

Dale, Sage 4.04.T.B-01

Dallmann, Natalie 5.08.P-Tu133

Dalsky, Ellie 1.06.T-04, 2.13.P-Th242, 2.13.P-Th243, 4.09.P-We076

Dalton, Rebecca 1.09.P-Tu120, 1.09.P-Tu121, 1.09.T.A-05, 4.03.P-Th164, 4.17.P-Tu232, 4.17.P-Tu237, 7.08.P-Tu137

Dalton, Rebecca L. 4.18.P-Tu283

Damiani Quiroz, Magdalena 2.01.P-Tu089

Damien Biot-Pelletier, Damien 8.02.P-We257

Dang, Huy 4.19.T-01

Daniel, Jon 4.24.P-We233

Daniels, Jordan 5.09.P-Tu287

Danielson, Tom 2.10.P-We100, 4.17.P-Tu242

Darius, Taiana 1.07.P-We097

Das, Krishna 3.03.P-Tu041

Das, Ratul Kumar 4.15.P-Tu185

Das, Tonoy 2.07.P-We057

Dashti, Nasrin 4.25.P-Th192, 4.25.T-05, 4.25.T-06

DaSilva, April 6.02.P-Th112

Daugherty, Katie 5.07.T-06

Dave, Sejal 2.02.P-Th262

Davenport, Erik 4.18.P-Tu273, 7.10.P-Tu300

Davidson Raoelison, Onja 8.05.P-We215

Davies, Ellie 4.01.P-Th157

Davies, Holly 8.08.T-02

Davies, Iain 5.14.T-06

Davies, Joanna 3.06.T-06

Davis, Cristina 4.19.T-06

Davis, Kallie 5.02.T.A-04

Davis, Ryan 3.04.P-We310

Dawe, Rachel 2.01.P-Tu085, 2.10.P-We099

Dawson, Daniel 5.14.T-02

Day, Matthew 1.02.P-We241

de Aquino, Sergio Francisco 4.11.P-We162

de Bruyn, Adrian 1.15.P-We198, 1.15.P-We203, 1.15.T-02

De Castro, Francine 2.03.P-Th001

de Jesus Silva, Kelly Cristina 2.10.P-We113

de Jourdan, Benjamin 1.03.T-04

De Maria, Maite 3.08.P-Th040

de Melo, Tomas 5.17.P-We265, 5.17.P-We266

De Oliveira, Ericka 4.05.P-Th131

De Orte, Manoela 2.02.T-03

De Orte, Manoela Romano 4.21.T-03

De Silva, Amila 1.02.P-We246, 2.10.P-We117, 3.07.P-Tu048, 4.04.P-Th100, 4.16.T-04, 4.19.T-05, 4.24.P-We228, 5.02.P-We280, 5.02.T.B-01

De Silva, Dinithi 4.16.T-03

de Solla, Shane 3.01.P-Th028, 3.01.T-02, 3.07.T.A-02, 3.07.T.A-04, 3.08.P-Th042, 3.08.P-Th045, 4.25.P-Th196

De Wolf, Christopher 4.21.T-01

Deberardinis, Jeff 5.02.T.A-04

DeForest, David 1.15.P-We198

Degeratu, Mihai-Ovidiu 1.02.T-06, 7.08.P-Tu135

Degli Esposti, Lorenzo 8.03.P-We003

Deglin, Sandrine 1.10.T-03

DeGroote, Caleb 7.08.P-Tu136

Dehaudt, Alexis 2.14.P-We188, 2.14.P-We196

Dehnert, Gavin 2.03.T-03, 5.07.T-04

Deible, Michael 4.27.T-03

Dejoie, Elsa 2.14.T-05, 4.26.T-02

Dekker, Tom 2.01.P-Tu089

Del Balso, Amanda 8.03.P-We007

Delâge, Danaëlle 4.17.P-Tu237

Delaplaine, Heather 4.06.P-Tu216

Delaunay, Delphine 7.04.T-03

Delbès, Géraldine 4.01.P-Th158

Deleris, Paul 2.07.P-We056, 2.07.T-02

Delgado Villatoro, Kathleen 7.11.P-Tu305

DeLorenzo, Marie 3.06.P-Tu103, 4.07.P-Tu144, 4.23.P-Tu156, 5.02.P-We276, 5.02.P-We277, 5.02.T.A-02, 7.02.T-03

Demaire, Camille 4.19.P-We209

Demers, Caroline 4.01.T-01, 4.05.T-03

Demers, Jason 2.06.T-02

Denis-legault, Benoît-Loup 3.06.T-04

Dennis, Alice 3.03.P-Tu041

Denslow, Nancy 1.04.P-Th168

Dereviankin, Mike 4.02.T-06, 4.07.T-01

Dergousoff, Melissa 4.14.P-We178

Dervilly, Gaud 2.07.T-02

DeSalvo, Anthony 5.02.P-We270

Desaulnier, Jean-Paul 5.17.P-We265, 5.17.P-We266

Desaulniers, Jean-Paul 5.17.P-We264, 5.17.P-We267

Desaulniers Brousseau, Vincent 8.01.T-03

Deschênes, Catherine 8.01.T-02

DeSilva, Ph.D., April 3.03.P-Tu043

Desjardins, Chloé 4.15.P-Tu183

Deslauriers, David 2.01.P-Tu081

Desreac, Flavie 1.01.T-03, 4.13.P-Th122

Detering, Claire 1.15.P-We203

Dewar, Audrey 4.01.T-03

DeWitt, Jamie 1.08.P-We170, 1.08.P-We171

Dextraze, Mathieu 4.17.P-Tu237

Dhakal, Kshitiz 5.18.P-We020

Dhaliwal, Seetal 1.09.T.A-06

Di Bengino, Sofia 7.02.P-Th207

Di Giulio, Richard 2.01.P-Tu080

Di Toro, Dominic 5.01.T-06

Diamond, Miriam 4.05.P-Th149, 4.16.P-Tu100, 4.22.T-02, 7.07.T-02, 7.10.P-Tu301

Diana, Zoie 4.15.P-Tu176

Diaz Basabe, Angelica 4.19.P-We208

DiBona, Elizabeth 4.22.P-Th217, 5.17.P-We258

diCenzo, George 4.24.P-We224

Dickens, David 2.06.P-Th115

Diehl, Dario 4.05.P-Th140

Dietrich, Jeremy 4.23.P-Tu150

Dietz, Rune 3.08.T-03

DiMarzio, Jenna 5.07.T-06

Dimitropoulos, Alexis 2.04.T-01

Ding, Jingran 4.24.V-01

Ding, Yunjie 2.03.P-Th014

Dion, François 2.14.P-We197

Discar, Josiah 5.02.T.A-01, 5.02.T.B-02, 6.03.P-Tu027, 6.03.P-Tu028

Disney, Jane 4.02.T-01

Dmitrenko, Olga 5.01.T-06

Dobrik, Molly 1.02.P-We242, 5.02.T.B-01

Dobson, Colin 4.02.P-Tu207, 6.03.P-Tu029

Dodard, Sabine 4.04.P-Th104

Dodd, Matt 4.07.P-Tu143

Doering, Jon 1.03.T-01, 1.03.T-04, 1.03.T-05, 1.03.T-06, 1.09.P-Tu119, 1.13.T-06

Doerksen, Aaron 4.04.P-Th105

Dolezal, Adam 1.08.P-We169

Domanico, Morgan 1.10.T-06

Dominato, Karlynne 4.15.P-Tu181

Domingues, Ines 1.13.P-Tu038

Dominguez, Gustavo 2.07.T-05

Donaher, Sarah 3.06.P-Tu111, 4.13.P-Th127, 4.13.P-Th128, 4.13.T-05

Donaldson, Jessica 1.04.P-Th174, 2.01.P-Tu092, 2.05.T-01, 4.06.P-Tu217

Dondero, Francesco 5.02.T.A-05

Dong, Jhih-Jyun 2.10.P-We122

Donkin, Jenna 2.13.T-05

Donova, Anna 8.09.T-06

Dorber, Martin 8.01.T-02

Doria Manzur, Alonso 4.06.P-Tu213

Dorman, Rebecca 1.06.T-01, 2.02.P-Th274, 4.17.P-Tu247

Dorrity, Michael 1.04.P-Th166

dos Santos Carvalho, Cleoni 2.01.P-Tu086, 2.10.P-We113

Dotson, Romina 2.01.P-Tu092, 3.08.P-Th052

Dougherty, Jennifer 2.13.T-04

Dourthe, Joris 2.07.P-We056

Dove, Alice 4.23.T-06

Dovichak, Aleksandra 2.13.T-05

Dow, Tyler 4.12.P-Tu258

Dowd, Georgina 7.07.T-03

Dowd, Sarah 4.21.P-Th154

Drevnick, Paul 1.15.P-We206

Drew, Simon 4.17.T-05

Driessen, Olivia 4.25.T-05

Driessnack, Melissa 2.13.T-02, 3.08.T-04, 4.26.T-01

Driscoll, Garrett 2.02.P-Th250, 2.10.P-We114, 7.02.P-Th207

Driver, Tim 8.01.T-03

Droge, Steven 5.15.P-Tu166

Droit, Arnaud 1.07.P-We097

Droz, Boris 5.01.T-05, 5.02.P-We281

Du, Xinyu 4.17.P-Tu231

du Hoffmann, Gunther 3.04.P-We310, 3.06.P-Tu113

Du Pasquier, David 1.13.T-03

Dubbs, Samantha 1.08.P-We169

Dubiel, Justin 1.03.T-04

Dubois, Geneviève 2.09.T-02

Dubois-Cote, Viviane 1.01.T-01

Dubuc, Catherine 2.09.T-06, 4.23.P-Tu155

Ducar, Scott 2.05.T-03

Ducasse, Carolanne 2.03.P-Th003, 2.05.T-05

Duchesne, Barbara 1.13.T-03

Duchesneau, Martin 4.01.T-01, 4.02.P-Tu193

Dudrick, Robyn 4.15.P-Tu175

Duethman, Charlie 4.04.T.B-01

Duffield, Aidan 4.04.T.B-01

Duffner, Andreas 5.15.P-Tu168

Duflot, Aurélie 2.01.P-Tu068

Duglas, Sathees 2.03.P-Th005

Duguay, Alexandra 8.06.P-Th187

Duhaime, Melissa 4.24.T-05

Duke, Bryand 6.02.P-Th111

Duke, Stephen 4.15.P-Tu187

Dumas, Pierre 4.21.P-Th154

Dummer, Paul 6.01.T-02

Dumont, Pascal 4.13.P-Th128

Dumont, Piper 4.04.T.B-01

Duncan, Candice 2.01.T.B-06

Dunn, Skylar 4.04.T.B-01

Dunnigan, James 1.15.T-03

Dupis-Smith, Reyd 4.04.P-Th096

Duplain-Laferrière, Frédérique 7.02.T-05

Dupont, Daniel 4.04.P-Th105

Dupuis-Smith, Reyd 4.04.P-Th095, 4.04.P-Th097

Durfee, Nicole 4.06.P-Tu215

Durham, Jeremy 4.04.T.A-03

Durier, Guillaume 2.05.T-05

Duris, Joseph 4.17.P-Tu241

Durone, Jean Bernard 8.04.P-Tu018

Duso, Angela 2.13.P-Th238, 4.17.T-03

Dutton, Jessica 2.12.P-We187, 4.04.P-Th092, 5.09.P-Tu287, 7.02.P-Th208, 7.02.T-04

Dwivedi-Leng, Maya 8.09.P-Tu314

Dyer, Scott 7.08.P-Tu138

Dykyi, Evgen 4.04.T.A-03

E

Eagles, Carter 2.07.P-We044

Eagles-Smith, Collin 2.12.P-We182, 3.02.T-03

Eagon, Lauren 1.03.T-01, 1.03.T-04, 1.03.T-05, 1.03.T-06, 1.09.P-Tu119, 1.13.T-06

Eakin, Carly 3.08.T-06

East, Andrew 3.01.P-Th031, 5.02.P-We272

Easton, Tony 1.14.P-Tu230

Ebanks, Sue 2.10.P-We119

Ebrahimi-Iranpour, Yashar 4.25.T-05

Ebrahimian, Ali 4.27.P-We300

Eccles, Kristin 1.09.P-Tu121

Eckhardt, Sabine 4.04.P-Th106

Edgar-Webkamigad, Elizabeth 7.07.T-01

Edge, Christopher 3.04.P-We308

Edwards, Michael 4.18.P-Tu273, 7.10.P-Tu300

Edwards, PhD, Daniel 3.06.P-Tu107

Eggers, Margaret 4.08.P-We029

Eggleton, Marisol 1.09.P-Tu121, 5.10.P-We148

Eguchi, Katsuhisa 2.10.P-We118

Ehalt Macedo, Heloisa 4.22.P-Th221, 4.22.P-Th229

Eisenreich, Karen 1.09.T.A-03

Ekechukwu, June 3.02.P-We036

EKPRUKE, CAROLYN 1.08.P-We174

Ekroos, Johan 8.01.T-03

El-Fateh, Mohamed 5.04.P-We249

El-Fityani, Tamzin 1.01.T-03

El-Zein, Abbas 1.12.P-Tu226

Elliot, Ashley 3.07.P-Tu048

Elliott, John 3.07.P-Tu051, 3.07.P-Tu052, 3.07.T.A-02

Elliott, Kayla 4.07.T-06

Elliott, Kyle 3.01.T-06, 3.07.T.B-04, 3.08.P-Th042

Ellis, Lee D 4.26.T-06

Ellis, Sian 5.05.P-We017

Ellison, Claire 8.02.T-01

Elpers, Taylor 4.09.P-We069

Elphick, James 1.15.P-We198, 1.15.T-05

Elston, Charlotte 5.15.P-Tu167, 5.15.P-Tu168, 5.15.P-Tu169, 5.15.P-Tu171

Emberley-Korkmaz, Sophie 1.05.T-05, 1.09.T.B-03, 2.02.P-Th257, 4.03.P-Th164, 4.05.P-Th137, 5.07.P-We165, 5.07.T-03

Embry, Michelle 1.13.T-02, 5.01.P-We059, 5.01.P-We060, 5.01.T-03, 5.01.T-04

Emeka, Onyinyechi 3.04.V-01

Emenike, Chijioke 6.03.P-Tu026

Emenike, Ebuka 2.10.P-We098

Emilson, Erik 2.12.P-We183

Emmanuel, Enyinnaya 8.06.V-01

Emmanuel, Nneka 3.06.P-Tu106, 8.06.V-01

Emmerton, Craig 1.15.P-We206

Endo, Kazuto 4.22.P-Th226

Endo, Satoshi 1.09.P-Tu126

Eng, Margaret 3.07.T.A-03, 3.08.P-Th036, 3.08.P-Th042

Eng, Margaret L. 3.04.P-We308

Eng, Quinn 1.09.P-Tu128, 4.13.P-Th125

Engelking, Sean 2.02.P-Th269

Entling, Martin 2.01.P-Tu089

Eom, Junho 2.08.P-Tu063

Eom, Taeeun 2.02.P-Th275

Erb, Trevor 4.05.P-Th133

Erickson, Andrew 2.13.T-01

Eriksson, Andreas 1.03.T-04

Eriksson, Nils 1.01.T-05, 2.02.P-Th276, 2.02.P-Th277

Erkhart, Matthew 8.09.T-05

Ernst, Isabelle 2.01.P-Tu089

Ertel, Bonnie 4.17.P-Tu236

Escher, Beate 1.09.P-Tu126

Esparza Magana, Ilse 3.01.T-06

Esser, Milena 5.04.P-We252, 5.04.T-04, 5.04.T-06

Estrada, Brady 2.03.P-Th002

Ethier, Adrienne 4.13.P-Th127, 4.13.T-02

Etienne, Ryder 5.07.T-03

Etterson, Matthew 1.03.P-Th018, 3.07.T.B-05

Evalgelou, Ioanna 4.24.P-We226

Evans, Kelly 2.01.V-02

Evans, Marlene 4.04.T.A-04

Evans Seeley, Meredith 4.17.P-Tu233

Evelyn, Ayesha 4.04.P-Th096, 4.04.P-Th097

Eytcheson, Stephanie 2.13.P-Th244, 4.17.T-02

Ezebuiro, Victor 6.05.V-02, 6.05.V-03

Ezechukwu, Happiness 6.05.T-05

F

Facciola, Nadia 4.04.P-Th100, 4.04.T.B-04

Fadhlaoui, Mariem 2.10.P-We116

Fages, Félix 1.03.P-Th019

Faillettaz, Robin 2.01.T.B-04

Fakunle, Mary 5.02.P-We274

Fallon, Alex 2.02.T-06

Fantke, Peter 8.08.T-02

Farag, Meiry 6.01.T-04

Fargette, Léa 2.01.P-Tu089

Farias, Sabrina 4.10.P-Tu003

Farrelly, Eamonn 3.07.P-Tu057

Farruggia, Frank 5.08.P-Tu130

Fassbender, Christopher 1.09.T.B-02, 5.09.T-02

Faßbender, Christopher 1.09.P-Tu124, 7.03.T-06

Fast, John 4.06.P-Tu212, 4.22.P-Th219, 4.22.T-06

Faulkner, Jared 4.10.P-Tu002

Faure, Antoine 2.10.P-We116, 4.23.P-Tu155

Fausett, Eric 4.06.P-Tu214

Fauteux, Dominique 4.04.T.B-06

Fay, Kellie 1.09.T.A-03

Fazioli, Kristi 3.07.P-Tu050

Federle, Thomas 5.14.T-06

Feerick, Anna 2.02.T-03, 4.21.T-03

Feifel, Mario 2.01.P-Tu089

Felismino, Miguel Eduardo 1.14.T-06

Félix Morales Paredes, Lino 2.10.P-We113

Femi-Oloye, Oluwabunmi 5.03.P-We212, 5.03.P-We213, 5.03.P-We214

Fender, Chloe 4.18.P-Tu276

Feng, Jiali 4.16.T-03

Fenner, Kathrin 4.09.T-01

Feral, Kehau-Lani 1.07.P-We097

Fergiev, Eden 4.12.P-Tu256, 4.19.P-We209

Ferguson, Lee 4.21.T-06

Ferguson, Steve 4.04.P-Th094, 4.04.P-Th100

Ferguson, Steven 3.08.T-03, 4.04.T.B-04, 4.04.T.B-05

Ferland, Troy 4.01.T-02

Fernald, Katrina 3.07.T.B-01

Fernández, José F. 8.03.T-02

Fernández-Rendón, Carlos 2.02.P-Th280, 3.06.P-Tu115

Fernie, Kim 3.01.T-01, 3.01.T-05, 3.01.T-06, 3.08.P-Th046

Fernie, Kim J. 3.08.P-Th045

Ferrer, Amanda 1.10.P-We303

Fetke, Janine 1.09.T.A-03

Fetters, Kyle 2.07.T-06, 3.08.P-Th033, 5.10.P-We130

Field, Emma 2.09.P-Tu032, 5.02.P-We288

Field, Jennifer 5.01.T-05, 5.02.P-We281

Figuière, Romain 8.08.T-02

Fillion, Michelle 1.15.P-We200

Fillion, Myriam 2.12.P-We184

Fischer, Fabian 3.02.P-We032

Fischer, Joshua 5.18.P-We019

Fischer, Lisa 1.01.P-Tu014

Fischer, Melanie 1.09.P-Tu124, 7.03.T-06

Fischer, Thom 2.01.P-Tu072

Fisher, Karen 5.07.T-02, 7.07.T-03

Fisher, Mandy 5.10.P-We128

Fisher, Rebecca 5.16.P-We298

Fisher, Richard 5.09.P-Tu295

Fisher, Stephanie A. 5.04.T-01

Fisk, A. T. 4.07.T-01, 4.12.P-Tu254

Fitzwilliam, Alexa 5.07.P-We165, 5.07.T-03

Fleming, Gregory 3.08.P-Th038

Fleming, Margaret 5.14.T-06

Flick, Lauren 2.07.P-We051

Flores, Juleanne 2.02.P-Th258, 2.13.T-05

Flores del Pino, Lisveth 5.09.V-01

Floyd, Yuki 1.12.P-Tu222

Flynn, Claudia 5.07.T-03

Flynn, Kevin 1.05.P-Th181, 1.05.P-Th182, 1.05.T-02, 1.05.T-03, 1.06.P-Th026, 1.06.T-05, 1.10.T-02

Focks, Andreas 5.08.P-Tu129, 5.15.P-Tu166

Fojut, Tessa 4.23.T-04

Fonseca, Jose Luis 1.10.T-05

Fontaine, Justine 5.02.P-We278, 5.16.T-06, 6.03.P-Tu025

FONTAINE, Ophélie 2.14.T-02

Fontenot, Patricia 1.09.T.A-03

Forbes, Valery 5.08.P-Tu129, 5.18.P-We024

Fordree, Nicole 4.04.P-Th098

Forsberg, Joan 4.04.P-Th092

Forsberg, Norman 1.01.P-Tu011

Fortin, Claude 1.01.T-03, 1.05.P-Th185, 2.01.P-Tu083, 2.02.P-Th253, 2.14.P-We194, 2.14.P-We195, 2.14.P-We196, 2.14.T-01, 2.14.T-04, 4.04.P-Th088, 4.04.P-Th089, 4.04.T.B-02, 4.13.P-Th122, 4.13.P-Th124, 4.14.P-We176, 4.18.P-Tu279, 4.18.P-Tu280, 4.19.T-01

Fortin, Heidi 2.14.P-We194

Foster, Madison 1.15.P-We200

Fournier, Anais 3.07.T.B-06

Fowler, Jerrett 5.08.P-Tu130

Fox, David 5.16.P-We290, 5.16.P-We291

Fracacio Francisco, Renata 2.10.P-We113

Fracácio Francisco, Renata 2.01.P-Tu086

Fragki, Stella 4.03.T-01

Frank, Ashlea 5.18.P-We022

Frank, Richard 2.06.P-Th114, 2.06.P-Th120

Frankel, Tyler 2.01.T.B-06, 2.02.P-Th250, 2.10.P-We101, 2.10.P-We114, 7.02.P-Th207

Franklin, Meredith 7.10.P-Tu301

Fraser, Christopher 5.10.P-We148

Fraser, Gareth 2.07.T-03

Fraser, William 5.10.P-We128

Frazier, Bryan 2.01.P-Tu092, 3.08.P-Th052

Fredlund, Matthew 4.04.P-Th101

Freeling, Finnian 4.09.T-05

Freeman, Elaine 5.10.P-We145

Fremdt, Heike 5.15.P-Tu168

Fremlin, Kate 3.07.P-Tu052

Frenchmeyer, Meredith 1.01.P-Tu011, 3.04.P-We309

Fried, Kristian 5.14.T-02

Friedenberg, Nick 5.18.P-We020

Friend, Ethan 2.01.P-Tu092

Fries, Eric 4.05.P-Th131, 4.24.P-We218, 4.24.T-02

Frighetto, Paulo Donato 2.01.P-Tu086, 2.10.P-We113

Frigon, Dominic 8.02.T-04, 8.02.T-06

Frisch, John 5.06.P-We237

FRITSCH, Clémentine 3.08.P-Th044

Froese, Duane 2.06.T-01

Fuchsman, Phyllis 1.07.P-We095, 2.07.T-06, 3.08.P-Th033, 5.10.P-We130

Fudala, Katarzyna 4.04.T.A-03

Fujisaki, Hiroshi 2.10.P-We118

Fukugami, Shusaku 4.09.P-We071

Fulcher, M. Leslie 1.08.P-We172

Funk, David 2.03.T-01

Funk, Frederik 4.24.P-We231

Furlow, J. David 4.21.P-Th147

Fuzzen, Meghan 2.01.P-Tu085

G

G. Botte, Gerardine 4.22.T-05

Gadberry, Cerasela 3.03.P-Tu043, 6.02.P-Th112

Gagne, Francois 4.18.P-Tu266

Gagné, Matthew 1.09.P-Tu121

Gagnon, Christian 4.01.P-Th162, 4.18.P-Tu266

Gagnon, Rébecca 1.02.P-We241

Galar-Martínez, Marcela 2.01.P-Tu094, 2.01.P-Tu095

Galiano, Angélique 2.14.P-We196

Galic, Nika 1.03.T-02, 5.08.P-Tu133

Gallagher, Fiona 4.09.P-We075

Gallagher, Jeffrey 1.03.T-03, 2.02.P-Th272

Gallagher, Sean 2.03.T-02

Gallant, Melanie 2.07.T-01

Gallilee, Carys 2.13.P-Th238, 4.23.P-Tu153

Galloway, Ashley 2.01.P-Tu092, 3.08.P-Th052

Galloway, Tamara 2.05.P-We039, 2.07.T-05, 4.05.T-01, 4.22.P-Th225

Gamal El-Din, Mohamed 2.06.T-04

Gamberg, Mary 3.07.T.A-02, 4.04.T.A-04

Ganci, Aristide 4.02.P-Tu192

Gandhi, Chintan K 5.10.P-We128

Ganglbauer, Johanna 4.09.P-We069

GAO, XIAOYU 8.03.T-01

Gaona-Colmán, Elizabeth 4.25.P-Th192

Garber, Kristina 1.03.P-Th018, 3.07.T.B-05, 5.08.P-Tu130

Garcia, Gustavo 2.07.P-We047

Garcia, Julia Losana 2.01.P-Tu089

Garcia, Paula 1.13.T-03

Garcia Reyero Vinas, Natalia 1.06.P-Th027

García-Medina, Alba Lucero 2.01.P-Tu094

García-Medina, Sandra 2.01.P-Tu094, 2.01.P-Tu095

Gardinali, Piero 2.10.P-We098, 4.12.P-Tu256, 4.18.P-Tu263, 4.21.T-02, 4.24.P-We222, 4.27.P-We300

Garnier, Jean-François 4.02.P-Tu192

Garrett, Scott H. 5.10.P-We126

Garrow, Thomas 5.10.P-We126

Garza, Emma 2.08.P-Tu064, 2.08.P-Tu065, 2.08.P-Tu066

Gasink, Joey 2.02.P-Th250

Gastaldi, Angela 4.04.P-Th105

Gates, Will P. 1.12.P-Tu226

Gaudet, Alexane 2.14.P-We193

Gauriat, Bénédicte 4.02.P-Tu192

Gauthier, Charles 2.14.P-We197

Gauthier, Jeremy 4.19.T-05

Gavel, Heidi 2.01.T-05, 2.02.P-Th260, 2.02.P-Th268, 6.03.P-Tu023

Gawra, Janan 1.04.P-Th167

Gearhart, Jeff 4.24.P-We218

Gedge, Ashley 5.17.P-We267

Geffard, Olivier 2.01.P-Tu068

Geitner, Nicholas 5.15.P-Tu171

Gélinas, Alexandra 6.01.T-01

Gellert, Gabriel 3.08.P-Th041

Geng, Fanshu 4.09.T-03

Genthe, Bettina 4.18.V-02

George, Robert 4.05.P-Th139, 6.03.P-Tu028

George, Saji 1.08.P-We168, 4.07.T-04, 4.24.P-We221

George III, John 4.02.P-Tu192

Geraci, Ethan 2.07.P-We055

Gergs, Andre 1.06.P-Th027

Gerhard, Jana 5.08.P-Tu133

Gerhold, Richard 3.07.P-Tu056

Gerring, Aviva 4.07.T-01

Gewurtz, Sarah 4.22.P-Th231, 4.22.T-04, 5.16.T-06

Ghahremani, Diba 4.27.P-We301

Ghanbari, Hamid 2.01.T.B-02

Gharouni Saffar, Sara 5.04.T-04

Ghasempouri, Mahmoud 2.07.P-We053

Ghosh, Rajat S. 4.14.P-We177

Ghoshal, Subhasis 1.14.T-02, 4.07.T-04, 4.15.T-01, 8.03.P-We007, 8.03.T-01, 8.03.T-05

Ghribi, Salem 8.03.P-We003

Ghyzel, Ann 4.23.P-Tu150

Giancarlo, Leanna 2.02.P-Th250, 2.10.P-We101, 2.10.P-We114

Gibson, Claire 8.02.T-06

Gibson, Nora 4.21.T-05, 4.22.T-03

Gibson-Banks, Kesley 2.12.P-We187

Gigault, Julien 4.04.P-Th103, 4.04.T.B-06, 4.15.T-01, 4.24.P-We224

Gilbreath, Alicia 2.13.T-04, 4.17.T-01

Gill, Brian 5.08.P-Tu130

Gill, Stephanie 4.17.P-Tu249

Gillet, Antoine 4.01.P-Th158

Gillett, David 4.05.P-Th140

Gillis, Patricia 2.05.T-04, 2.06.P-Th120, 4.25.P-Th196, 5.02.P-We280

Gillissen, Frits 2.01.T.A-03

Gilron, Guy 1.01.P-Tu012

Gilroy, Ève 1.02.P-We246, 2.10.P-We117, 2.14.P-We190

Gimbert, Frédéric 3.06.T-05

Gindorf, Sven 2.01.P-Tu088

Giovenazzo, Pierre 4.01.T-03

Girard, Catherine 1.02.P-We241

Giroux, Eloïse 2.14.P-We189

Giuliano, Alexandra 2.09.P-Tu033, 6.03.P-Tu024

Givens, Carrie 4.23.T-05

Gjashta, Xhoen 2.13.T-06

Gjeltema, Jenessa 3.08.P-Th051

Gjerdrum, Carina 1.03.P-Th019

Glasner Regis, Cintia 2.07.T-01

Gleason, Amber 2.14.T-05, 4.26.T-02

Gleason, Daniel 2.05.T-02

Glienke, Judith 4.06.P-Tu219, 4.24.P-We225

Glinski, Donna 1.04.P-Th175

Gobas, Frank 2.06.T-04

Gobbi, Kimbrie 4.02.P-Tu208

Gobeil, Allie 2.07.T-06

Godoy, Natalia B. 4.11.P-We161

Godwin, Sean 2.02.P-Th278

Goetz, Amber 5.10.P-We145

Goetz, Gunnar 4.17.P-Tu246

Goin, Jessica 4.12.P-Tu257

Goldstone, Jared 1.06.T-06

Gómez Canela, Cristian 1.04.P-Th167

Gómez Maldonado, Maria Concepción 5.09.P-Tu298

Gomez Zea, Paula 4.01.P-Th159

Gómez-Oliván, Leobardo Manuel 2.01.P-Tu094

Gondaliya, Akash 8.09.T-05

Gondek, John 5.02.P-We283

Gong, Yufeng 4.01.P-Th156

Gong, Yuki 2.06.T-04

Gonsalves, Sydney 2.05.P-We043

Gonsior, Michael 5.14.T-06

Gonzales, Annelise 4.13.T-05

Gonzalez, Melissa 2.13.T-02

González Martínez, Farith 1.07.P-We092

Gonzalez-Estrella, Jorge 4.10.P-Tu003

Gonzalez-Martinez, Farith 5.10.P-We141

Good, Samantha 4.22.T-01

Goodfellow, William 4.22.P-Th228, 7.12.T-01

Goodin, Cecilia 2.08.P-Tu064, 2.08.P-Tu065, 2.08.P-Tu066

Goodrum, Philip 3.04.P-We305, 5.02.P-We286

Gooley, Benjamin 4.26.P-Th283

Gordon, Stephanie 2.04.T-05, 4.17.P-Tu241, 4.17.T-04

Gorham, Justin 4.15.T-02

Gorney, Rebecca 4.17.P-Tu241

Gosselin, Louis 8.01.T-04

Goulet, Richard 1.01.T-03, 4.13.P-Th123

Gourand, Julien 2.01.P-Tu068

Govindu, Sreedevi 5.05.P-We016

Gowdy, Kymberly M. 1.08.P-We172

Grace, Richard 2.13.T-04, 3.07.P-Tu045

Gradito, Maryane 3.07.V-01

Graichen, Adam 4.08.P-We030

Granados Galvan, Alejandra 4.24.P-We228

Granados-Martínez, Karol 7.05.P-We157

Grant, Kelly 8.08.T-02

Grant-Weaver, Iain 4.14.P-We178

Grasman, Keith 3.07.T.A-01, 3.08.T-06, 7.04.T-06

Grassi, Giacomo 1.09.T.B-02, 5.09.T-02

Gray, Andrew B. 4.17.P-Tu233

Gray, James 4.08.P-We029

Gray, Queenie 2.06.T-02

Graydon, Jennifer 1.15.P-We206

Green, David 4.27.T-04

Green, Frank 5.15.P-Tu170

Green, Liam 4.24.T-03, 4.27.T-02

Green, Owen 1.13.P-Tu039

Greener, Jesse 4.24.P-We224

Greenfield, Sarah 5.07.T-06

Greer, Justin 1.06.T-04, 1.08.P-We167, 2.13.P-Th242, 2.13.P-Th243, 4.17.P-Tu241, 4.17.T-04

Greer, Kendall 2.01.P-Tu084

Grégoire, Daniel 6.05.T-02

Gregory, Erica 7.07.T-03

Gregory-Eaves, Irene 1.14.T-06, 2.01.T.B-02

Greidanus, Allysa 4.21.P-Th148

Greil, Amandine 4.04.P-Th089, 4.04.T.B-02

Grenon, Marie-Claire 4.01.T-01, 4.02.P-Tu193, 4.05.T-03

Griffith, Amelia 3.06.T-06

Griffith, Koral 2.13.P-Th245

Grigoropoulou, Afroditi 4.23.P-Tu149

Grimmelpont, Margot 1.15.T-03

Grinstead, Sydney 4.15.P-Tu182

Groh, Ksenia 1.02.T-06, 7.08.P-Tu135

Grommenau, sofia 2.01.T.A-04

Grosell, Martin 2.01.T.B-04

Grostic, Jason 8.03.P-We010

Grunden, Amy 5.05.P-We012

Grundy, Steve 4.07.P-Tu143

Grung, Merete 2.01.P-Tu078, 4.23.T-02

Gualandris, Davide 5.02.T.A-05

Guarino, Ashley 5.02.T.A-06

Guelfo, Jennifer 4.06.P-Tu213, 8.03.T-06

Guerin-Lajoie, José 2.09.T-02

Guerra de Navarro, Maria 2.10.P-We098, 4.12.P-Tu256, 4.18.P-Tu263

Guevara, Marco 5.09.P-Tu294

Guillette, Matthew 3.02.P-We033

Guillette, Theresa 3.02.P-We033

Guilmette, Caroline 4.04.P-Th103

Guimard, Léna 1.01.T-03, 2.10.P-We116, 4.04.T.B-02, 4.13.P-Th124

Guiney, Patrick 7.12.T-01

Guinle, Colleen 2.07.P-We056

Gulati, Ivana 1.10.P-We303

Gunsch, Claudia 6.01.P-We083

Guo, Anya 4.01.P-Th157, 4.01.T-06, 4.05.P-Th149

Guo, Jiehong 4.24.P-We229

Guo, Zhefei 4.25.T-02

Gurfield, Kalealani 4.27.T-05

Gurney, Kirsty 3.08.P-Th035

Gushgari, Adam 4.27.T-01

Gutierrez, Simon 4.24.P-We230

Gutiérrez-Pacheco, Joshua 4.15.P-Tu180

H

H. Adams, Douglas 2.14.P-We192

H. B. Beach-Diplock, Norah 4.21.P-Th150

Haas-Neill, Sandor 4.14.P-We178

Habekost, Maike 5.11.P-Tu165

Haber, John-Paul 2.03.P-Th007

Haberle, Ines 5.18.P-We024

Habimana, Emile 5.16.T-06

Habtemichael, Asta 4.09.P-We069

Haché, Geneviève 6.05.T-02

Haddad, Samuel 4.06.P-Tu214

Hadria Gondry, Karima 4.02.P-Tu193, 4.04.P-Th089, 4.04.T.B-02

Haferkemper, Leonie 2.01.P-Tu088

Hafner, Jasmin 4.09.T-01

Hafner, William 4.02.P-Tu208

Haga, Yuya 4.15.P-Tu189

Hahn, Daniel 6.01.T-05, 6.02.P-Th110

Haile, Tadele 2.13.P-Th244

Haimbaugh, Alex 2.02.P-Th251, 5.02.T.A-06

Hainzenreder Bauer, Luana 2.14.P-We192, 4.13.P-Th124

Hajiyev, David 4.12.P-Tu256, 4.18.P-Tu263

Halappanavar, Sabina 1.07.P-We091, 1.09.P-Tu121

Halde, Caroline 4.23.P-Tu152

Hale, Elizabeth 1.07.P-We090

Hale, Robert 4.15.P-Tu174

Hall, Jack 2.08.P-Tu062

Hall, Jennifer 2.03.P-Th005

Hall, Michael 2.02.P-Th265

Hall, Natalie 4.17.P-Tu241

Hall, Tilghman 5.18.P-We022

Halldorson, Thor 4.04.P-Th095, 4.04.P-Th096, 4.04.P-Th097, 4.07.T-01, 4.12.P-Tu254

Halvorsen, Helene Lunder 4.04.P-Th106

Hamid, Naima 4.15.P-Tu187, 7.05.P-We155

Hamilton, Bonnie 2.03.P-Th007, 4.15.P-Tu176, 4.24.T-02

Hamilton, Mariska 1.06.T-02

Hamilton, Markis' 4.22.P-Th224

Hamilton-Brehm, Scott 2.01.P-Tu092

Hamm, Jack 2.01.T.B-01

Hamm, Jonathan 1.09.T.B-04

Han, Biyao 3.07.T.A-03

Hanana, Houda 2.03.P-Th013

Hancock, Gregg 4.15.P-Tu191

Hang, Spencer 1.09.P-Tu128, 4.13.P-Th125

Hannadige, Dinuka 4.22.P-Th237

Hansen, John D. 4.09.P-We076

Hansen, John 1.06.T-04, 1.08.P-We166, 1.08.P-We167, 2.13.P-Th242, 2.13.P-Th243, 4.17.T-04

Hanson, Ava 5.08.P-Tu130

Hanson, Mark 2.06.T-05, 2.08.P-Tu059, 2.08.P-Tu060, 2.08.P-Tu061, 4.04.T.B-03, 4.25.P-Th191, 5.02.T.B-03, 6.01.P-We082

Hanson, Rowan 3.07.P-Tu057

Hansra, Simran 2.03.P-Th010

Hansul, Simon 5.08.P-Tu134

Hapich, Hannah 4.17.P-Tu233

Hara, Junko 4.24.P-We223, 4.24.P-We232

HARA, Akihiro 4.22.P-Th226

Harford, Andrew 1.01.T-05, 2.02.P-Th276, 2.02.P-Th277

Harland, Danika 2.08.P-Tu060

Harmon, Sarah 2.10.P-We103

Harner, Tom 4.18.P-Tu283

Haroune, Lounès 3.01.P-Th032, 3.03.P-Tu041, 3.07.P-Tu055, 3.07.T.B-02

Harper, Bryan 1.12.P-Tu221

Harper, Stacey 1.12.P-Tu221, 4.24.P-We235

Harper (Sofield), Ruth 2.10.P-We125

Harre, Kathrin 2.13.T-06

Harrington, Cameron 4.23.T-03

Harris, Keegan 4.21.P-Th151

Harris, Melissa 2.03.P-Th014

Hart, Don 4.13.T-01

Hart, Edward 6.03.P-Tu028

Hart, Leslie 3.07.P-Tu050

Hart-Cooper, William 2.13.P-Th242

Hartmann, Erica M. 5.04.T-01

Harwood, Amanda 2.08.P-Tu064, 2.08.P-Tu065, 2.08.P-Tu066

Harwood, Gyan 1.02.T-04

Harynuk, James 4.10.P-Tu002

Haselman, Jonathan 1.13.T-01

Hashmi, Safeer Islam 4.15.P-Tu188

Haskins, David 3.01.P-Th031

Haskins, David Lee 3.02.P-We036, 3.02.T-06

Hasman, David 4.17.T-03

Hassan Aghaei, Mina 4.23.P-Tu153

Hata, Akihiko 4.17.P-Tu234

Hatch, Lindsay 4.01.P-Th163, 4.07.P-Tu145, 4.19.P-We208, 4.21.P-Th154

Hatton, Haylee 4.04.P-Th093, 4.04.P-Th094

Hauck, Sloane 3.07.P-Tu054

Hauge-Rogers, Claire 4.05.P-Th139

Hausladen, Debra 4.13.T-02

Havens, Kirk 4.15.T-03

Havens, Patrick 5.11.P-Tu163, 5.11.P-Tu164

Havey, Michelle 2.05.P-We043

Hawabhay, Rheina 4.05.T-03, 4.17.P-Tu240

Haws, Anna 4.23.P-Tu150

Hayes, Kia 4.04.P-Th099

Hayes, Patrick 4.18.P-Tu264

Hayman, Nicholas 4.05.P-Th139, 4.05.T-05, 5.02.P-We284, 5.02.T.A-01, 5.02.T.A-03, 5.02.T.B-02, 6.03.P-Tu027, 6.03.P-Tu028

Hazlerigg, Charles 5.08.P-Tu129, 5.08.P-Tu132

He, Wenkui 4.23.P-Tu158

Head, Jessica 1.03.P-Th019, 1.03.T-04, 1.05.P-Th183, 1.05.T-04, 1.05.T-06, 1.09.P-Tu120, 1.09.T.A-05, 3.01.P-Th030, 3.01.T-01, 3.01.T-04, 4.05.P-Th137, 4.05.T-03, 4.17.P-Tu240, 8.08.P-Tu309

Headley, John 1.02.P-We240, 2.06.P-Th119

Headley, John V 2.06.P-Th113

Healey, Norm 2.12.P-We186, 2.13.P-Th239, 5.16.T-02

Healy, Hannah 4.10.T-02, 8.05.P-We216

Heaney, Yvonne 8.05.P-We217

Hebda, Christopher 4.17.T-05

Hebert, Craig 2.06.T-02

Hecker, Markus 1.01.T-05, 2.02.P-Th252, 2.02.P-Th258, 2.02.P-Th276, 2.02.P-Th277, 2.02.T-06, 2.13.T-05, 4.17.P-Tu250, 5.04.P-We253, 5.09.T-02

Hedayati Azar, Aysa 8.03.T-05

Hedd, April 1.03.P-Th019

Heddle, Cybele 1.15.P-We198, 1.15.P-We203, 1.15.T-02

Heimer, Robert 5.17.P-We261

Heisler, Ryan 1.09.T.B-02, 5.09.T-02

Helbing, Caren C. 2.09.T-01

Helbing, Caren 2.09.P-Tu032, 2.09.T-03, 2.09.T-04, 5.02.P-We288

Helbling, Damian 4.09.T-01, 4.09.T-03

Helland, Brad 4.02.P-Tu208

Helm, Paul 4.05.P-Th131, 4.07.T-01, 4.16.T-02, 4.22.T-02

Hendershot, Maxwell 1.06.T-06

Henderson, W. Matthew 1.04.P-Th175

Hengelbrok, Olivia 4.15.T-01

Hengesbach, Janet 8.03.P-We010

Henneberger, Luise 1.09.P-Tu126

Henriques, Cristina 2.10.P-We106

Henry, Chris 4.01.P-Th163

Henry, Kevin 1.07.P-We097

Hepworth, Emma 1.08.P-We173

Hermabessiere, Ludovic 4.26.T-06

Herman, Danielle 8.03.P-We007

Hermann, Markus 2.01.P-Tu088, 2.01.T.A-02

Hernout, Beatrice 3.08.P-Th047

Herrmann, Larissa 2.01.P-Tu090

Herron, Hunter 1.06.T-06

Hertelendy, Arabella 4.06.P-Tu217

Heselton, Matt 2.01.P-Tu092

Hetrick, Andrew 2.02.P-Th266

Heuvel, C. E. 4.07.T-01, 4.12.P-Tu254

Hewitt, Mark 2.05.T-04, 2.06.P-Th114, 2.06.P-Th120, 4.18.P-Tu283

Heyes, Andrew 5.14.T-06

Hickey, Gordon 7.08.P-Tu137

Hickmann, Silke 5.14.T-01

Hicks, Andrew 7.10.P-Tu301

Hicks, Steve 2.03.P-Th014

Hiff Hartz, Kara 7.10.P-Tu299

Higashisaka, Kazuma 4.15.P-Tu189

Higgins, Christopher 4.09.T-01

Higgins, Rachel 7.05.P-We154

Higgs, Sofia 3.07.T.B-04

Hiki, Kyoshiro 5.04.P-We247

Hildebrand, Lisa 4.24.P-We235

Hildebrandt, Alanna 2.13.P-Th245

Hill, Brandon 2.06.T-01

Hill, Bridgett 1.09.T.B-04

Hill, Liam 2.02.P-Th260, 2.02.P-Th268, 6.03.P-Tu023

Hill, Nick 4.26.P-Th283

Hill, Ryan 1.01.P-Tu012, 5.16.T-02

Hill, Sydney 4.04.T.B-01

Hilliard, Richard 4.02.T-01

Hillier, N. Kirk 3.04.P-We308

Hintelmann, Holger 2.12.P-We185

Hiroshi Fujiwara, Gabriel 2.01.P-Tu086

Hirtler, Adrianna 4.23.P-Tu150

Hladik, Michelle 2.13.P-Th242, 2.13.P-Th243, 4.23.T-05

Hladik, Michelle L. 4.23.P-Tu150

Ho, Harmony 5.02.P-We280

Hoang, Tham 2.03.T-05, 4.15.P-Tu187, 4.15.P-Tu188, 7.05.P-We155

Hoard, Lisa 2.05.T-04, 5.02.P-We280

Hoare, Jeremy 2.10.P-We099, 5.17.P-We262

Hocking, Morgan 2.09.T-03

Hodges, Geoff 1.05.P-Th180, 1.05.T-05

Hodges, Juliet 5.09.T-02

Hodson, Peter 2.06.T-05, 6.01.P-We082

Hoffman, Kate 4.06.T-05

Hoffmann, Felicia 2.01.P-Tu089

Hogan, Colin 7.05.P-We159, 7.05.P-We160

Hogan, Natacha 2.02.P-Th252, 2.02.P-Th258, 2.02.T-06, 5.04.P-We253

Hogberg, Helena 1.09.T.B-04

Hogberg, Helena T. 7.08.P-Tu136

Hoguet, Jennifer 4.18.P-Tu278

HOJO, Yuya 3.07.P-Tu058, 4.09.P-We071

Hokaku, Mii 4.15.P-Tu189

Holden, Patricia 4.06.P-Tu210

Holland, Erika 1.14.P-Tu230

Holland, Rayne 4.25.T-04

Hollebone, Bruce 2.06.T-05, 6.01.P-We082

Hollender, Juliane 2.01.P-Tu088, 2.01.T.A-02, 4.21.T-03, 4.23.P-Tu148

Holloway, Alison 2.06.P-Th114, 2.06.T-03

Holmes, Jamie 6.02.P-Th108

Hommen, Udo 5.08.P-Tu129

Honda, Hiroshi 2.07.P-We052

Hong, Jasmine 4.15.T-01

Hong, Jun Hwa 3.07.P-Tu047

Hong, Minki 2.13.P-Th247

Hood, Glynnis 4.14.P-We178

Hoogeweg, Gerco 5.18.P-We019, 5.18.P-We020

Hoos, Maximilian 7.08.P-Tu135

Hopkins, Kailee 3.01.T-01, 3.01.T-05, 3.08.T-03

Hopkins, Scott 4.21.P-Th148

Hopkins, W. Scott 5.17.P-We263

Hopkins, Zachary 3.02.T-06

Hoppenreijs, wout 2.01.T.A-04

Hornbuckle, Keri 4.05.P-Th132, 4.05.P-Th133, 4.21.T-05, 4.22.T-03

Hoskins, Bart 5.09.P-Tu295

Hosny, Mariam 8.09.P-Tu314, 8.09.T-02

Hossack, Blake 3.02.T-01, 3.02.T-03

Hotta, Asako 4.04.P-Th086

Houde, Magali 2.03.P-Th013, 3.03.P-Tu041, 3.07.P-Tu048, 4.04.P-Th094, 4.04.P-Th100, 4.04.T.B-04

Houédé, Marie 1.13.P-Tu037

Houle, Maylie 2.14.T-06

Hourtané, Océane 1.01.T-03

House-Knight, Tamara 5.09.P-Tu289, 5.10.P-We144

Howe, John 5.11.P-Tu163

Hoxie, Taylor 5.04.T-03, 5.04.T-05

Hoyle, Genevieve 1.15.P-We205

Hrenchuk, Lee 5.04.P-We253

Hsieh, Chi-Ying 2.10.P-We122

Hsieh, Jui-Hua 1.09.T.B-04

Hsiung, Caitlyn 2.10.P-We108

Hu, Morgan 1.02.T-02, 2.10.P-We112

Hu, Shao-Yang 2.10.P-We122

Hu, Zhiji 4.10.T-02

Hua, Jason 4.05.P-Th132, 4.05.P-Th133, 7.11.P-Tu305

Hua, Jessica 5.07.T-04

Huang, Ivan 4.07.P-Tu140

Huang, Weichun 1.02.T-02

Huayta ramirez, Javier 4.05.P-Th144

Hubbard, Laura 4.23.T-05

Hubley, Raina 5.04.P-We251, 5.04.T-06

Huchthausen, Julia 1.09.P-Tu126

Huddleston, George 5.02.T.B-04, 5.10.P-We149

Hughes, Kimberley 3.01.P-Th028, 3.07.T.A-02

Humeniuk, Braedon 2.08.P-Tu059, 2.08.P-Tu060, 2.08.P-Tu061

Humpheys, Megan 2.01.T.B-03

Hung, Elli 1.05.T-06, 2.08.P-Tu061, 4.05.T-03, 4.17.P-Tu240

Hung, Hayley 4.01.T-04, 4.05.P-Th134, 4.19.P-We210, 4.25.T-03

Hunnie, Blake 1.10.P-We303, 2.02.P-Th258, 2.13.T-05

Hunter, Margaret 3.08.P-Th040

Hunter, Sam 2.12.P-We183

Hussain, Shehnaz 4.19.T-06

Hussey, Nigel 4.04.T.B-05

Hussherr, Rachel 2.09.T-02

Hutton, Sara 1.09.P-Tu117, 5.02.P-We273

Hwang, Shinjeong 5.06.P-We238

Hwang, Sung Ho 1.02.P-We244

Hyder, Christopher A. 1.15.P-We200

Hynds, Paul D 8.02.T-05

Hyun, Seunghun 8.06.P-Th186

I

Iafisco, Michele 8.03.P-We003

Idehara, Wakaba 4.15.P-Tu189

Idogar, Caroline 5.10.P-We131

Idowu, Ifeoluwa Grace 4.07.T-01

Igboamalu, Dr. Chinenye Amarachukwu 4.18.V-01

Ihn, Yunchul 5.09.P-Tu292

IKENAKA, Yoshinori 3.08.P-Th043, 4.23.P-Tu160

Ikuno, Yudai 4.15.P-Tu189

Imamura, Kazuki 2.02.P-Th271

Imazeki, Sana 2.02.P-Th271

Imbleau Chagnon, Guillaume 8.09.T-05

Immobile Molaro, Greta 5.02.T.A-05

Imroatushshoolikhah, Imroatushshoolikhah 2.01.T.A-04

Ina, Ebert 5.14.T-01

ineda-Enriquez, Tania 8.05.P-We215

Ingels, Brecht 5.08.P-Tu129

Inoue, Go 4.02.P-Tu203

Inoue, Takashi 2.10.P-We118, 7.04.T-05

Ionescu, Serena 5.07.T-03

Iqaluk, Debbie 4.04.P-Th091, 4.04.T.A-04, 4.04.T.A-05

Irvine, Mark 4.04.T.A-03

Irving, Elaine 2.02.P-Th265

Ishizuka, Mayumi 3.08.P-Th043

ISHIZUKA, Mayumi 4.23.P-Tu160

Ishola, Abdul 5.10.P-We131

Issac, Fleur 4.04.P-Th089, 4.04.T.B-02

Isukuru, Efe 2.08.P-Tu067

Itaki, Takuya 4.24.P-We236

Ito, Koji 4.22.P-Th226

Ivan, Lori 1.06.T-02, 8.03.P-We010

Ivanchenko, Pavlo 8.03.P-We003

Ivantsova, Emma 5.02.P-We282

Ivy, Catherine 3.01.T-03

Ivy, Nathan 2.13.T-02

Iwalaye, Oladimeji Ayo 4.26.T-04

Iwasaki, Yuichi 5.01.P-We062, 5.10.P-We146

Iwuagwu, Mary 3.06.P-Tu106, 6.05.T-05, 8.06.V-01

Iyawe, Vincent 1.08.P-We174

J

J. Rulli Jr., Samuel 8.08.P-Tu309

Jaansalu, Matthew Jaansalu 1.04.P-Th170

Jaborek, Jerad 8.03.P-We010

Jacinto, Tyler 5.05.P-We013

Jackson, Brian 2.12.P-We187

Jackson, Jeremy 1.01.P-Tu013

Jacobs, Mike 2.09.T-03

Jacobs, Molly 8.08.T-02, 8.08.T-06

Jacova, Ruben 2.14.P-We197

Jagla, Magdalena 4.17.P-Tu232, 4.17.P-Tu237, 5.10.P-We148

Jahin, Afia 8.02.T-04, 8.02.T-06

Jaiman, Rosa 7.05.P-We154

Jaisi, Deb 8.03.P-We003

Jakoby, Oliver 5.08.P-Tu129

Jamal, Sondus 4.22.P-Th215, 4.22.P-Th216

James, Alan 2.08.P-Tu062

James, Christopher 2.10.P-We125

Jankowski, Mark 1.08.P-We167

Jansohn, Hannah 2.01.P-Tu089

Janson, Christopher 1.03.T-03

Janssen, Sarah 2.12.P-We182, 4.04.T.A-06

Jansson, Stina 5.01.T-01

Jantunen, Liisa 2.01.V-02, 4.04.P-Th093, 4.04.P-Th094, 4.16.T-03, 4.24.P-We228

Jantunen, Liisa M. 4.04.T.A-02, 4.16.T-01

Janz, David 1.01.T-03

Jaramillo, Lauren 7.10.P-Tu302

Jardine, Claire 3.07.T.B-03

Jardine, Tim 2.01.T.B-01, 3.08.P-Th053, 4.04.P-Th105

Jardine, Timothy 4.04.T.A-05

Jarron, Samantha 2.03.P-Th015

Järviö, Natasha 8.01.T-03

Jarvis, Simone 1.04.P-Th175

Jarvisto, Johanna 2.02.P-Th276

Järvistö, Johanna 1.01.T-05, 2.02.P-Th277

Jasinski, Daniel 2.07.P-We047

Jat, Prahlad 4.05.P-Th136, 4.26.P-Th284

Jaumot, Joaquim 1.04.P-Th166

Jayasundara, Nishad 2.01.P-Tu080

Jazan, Elisa 8.03.P-We008

Jean, Mélanie 4.13.T-04

Jeanne, Jason 2.01.P-Tu068

Jeannot, Cassandre 2.07.T-02

Jeffcoat, Paris 7.08.P-Tu137

Jefferies, Laura 4.23.T-03

Jeffries, Cameron 4.13.P-Th127

Jeffries, Ken 2.01.P-Tu091

Jeffries, Kenneth 2.08.P-Tu061

Jenckes, Jordan 4.04.T.A-06

Jennings, Elaine 4.24.P-We230

Jennings, Ramsey 4.04.T.B-01

Jenny, Flurin 4.09.T-01

Jensen, Kathleen 1.06.P-Th026, 1.06.T-05, 4.19.P-We207

Jensen, Signe M. 5.16.T-04

Jeon, Jun Hui 4.15.P-Tu186

Jeon, Ye Jee 4.15.P-Tu186

Jeon, Yejee 4.18.P-Tu282

Jermilova, Una 2.12.P-We185, 5.16.P-We293

Jernberg, Johanna 2.13.P-Th244

Jesus, Bruno 2.07.P-We056

Ji, Kyunghee 1.02.P-We244, 1.06.P-Th021, 1.06.P-Th023, 1.06.P-Th025, 1.07.P-We089, 2.02.P-Th264, 2.02.P-Th275

JI, KYUNGHEE 5.06.P-We239

Jia, Tianqi 4.04.T.B-03

Jiang, Yun 5.09.P-Tu294

Jilkova, Rozarka 4.16.V-01

Jimenez, Ana 5.09.P-Tu294

Jimenez Lamana, Javier 2.14.T-02

Jin, Hohyun 4.17.P-Tu251

Jing, Siyuan 5.09.V-01

Jirsa, Michael 2.10.P-We124

Jobst, Karl J. 4.01.T-03

JOEL, NWAOGWUGWU 5.10.P-We151

Johannsson, Ora E. 2.08.P-Tu063

Johnsen, Philip 2.03.P-Th007

Johnson, Aaron 3.02.P-We036

Johnson, Benjamin 5.07.T-06

Johnson, Caitlin 5.07.T-06

Johnson, Connor 2.02.P-Th279

Johnson, Gavin 2.03.P-Th014

Johnson, Mark 3.04.P-We305

Johnson, Markey 5.10.P-We128

Johnson, W. Edward 4.18.P-Tu273

Johnson-Restrepo, Boris 1.07.P-We092, 5.10.P-We141

Jones, A. Daniel 1.06.T-02, 8.03.P-We010

Jones, Alan 2.02.P-Th255, 5.11.P-Tu165, 7.03.T-04

Jones, Daniel 2.04.T-05, 4.17.P-Tu241, 4.17.T-04

Jones, Gabrielle 4.17.P-Tu236

Jones, Gerrad 5.02.P-We281

Jones, Jasmine 2.07.P-We047, 4.06.T-03, 8.03.P-We009

Jones, Jen 2.07.T-05, 4.05.T-01

Jones, Kelly 5.09.T-04

Jones, Parker 2.02.P-Th258, 2.13.T-05

Jones, Paul 2.01.T.B-01

Jones, Steph 5.01.T-04

Jongsma, Gregory F.M. 3.02.P-We035

Jonsen, Philip 4.15.T-06

Jordaan, Sarah 8.09.P-Tu311, 8.09.P-Tu313, 8.09.P-Tu314, 8.09.T-02, 8.09.T-06

Jordaan, Sarah M. 8.01.T-06

Joudan, Shira 4.02.P-Tu206, 4.04.T.B-03, 4.10.P-Tu002, 4.10.P-Tu005, 4.10.P-Tu006, 4.18.P-Tu274, 4.19.P-We211, 4.24.P-We220, 4.25.P-Th191, 4.25.T-02

Jouy, Thibaut 2.14.P-We193

JOY, IGWE 5.10.P-We151

Joya, Jakiya Sultana 6.05.T-03

Juárez-Salinas, Carlos 3.06.P-Tu115

Juba, Nicole 5.05.P-We012

Jubeaux, Guillaume 2.01.P-Tu068

JUDE, IGWE 5.10.P-We151

Julha de Almeida Santos, Ana 2.10.P-We104

Juneau, Philippe 2.01.P-Tu093

Jung, Hyeonju 4.05.P-Th143

K

K, Sangeeth 4.24.P-We221

Kabir, A. H. M. Enamul 4.24.P-We228

Kadadou, Dana 4.15.P-Tu173, 4.24.P-We219

Kadlec, Sarah 5.01.T-02

Kagey, Samantha 2.03.P-Th014

Kahan, Tara 1.10.P-We303

Kainamu, Ani 7.07.T-03

Kakulu., Iyenemi 3.04.V-01

Kaldor, Amos 2.02.P-Th270

Kalogerakis, Georgina 2.03.P-Th007, 4.15.P-Tu173

Kalve, Erica 2.02.T-03, 4.21.T-03

Kaminsky, Heather 2.06.T-04

Kandhadai, Sree 4.09.P-We073

Kaneseki, Kazuki 2.10.P-We118

Kang, Joo-Yeon 5.10.P-We137

Kannan, Krishnaveni 4.22.P-Th233

Kannan, Unnikrishnan 4.24.P-We221

Kannangara, Miyuru 8.09.T-05

Kannankeril Khalid, Nejumal 3.08.T-01

Kansal, Nyssa 1.12.V-01

Kanz, Abraham 3.07.T.B-01

Karaoglan, Bilgin 5.05.P-We011

Karimifard, Shahab 2.01.P-Tu072

Karimpour, Shooka 2.02.P-Th262

Karlsen, Odd 1.03.T-04

Karlsson, Torbjörn 1.01.T-05, 2.02.P-Th276, 2.02.P-Th277

Karouna-Renier, Natalie 3.01.P-Th031, 3.01.T-01, 3.02.T-06, 6.01.T-02

Karschnik, Travis 5.06.P-We237

Kashiwabara, Lauren 4.24.P-We235

Kasparek, Alex 1.05.P-Th182, 1.06.P-Th026, 1.06.T-05, 1.10.T-02

Kasperkiewicz, Alexander 4.01.T-04, 4.05.P-Th134, 4.19.P-We210, 4.25.T-03

Kassotis, Christopher 4.24.P-We218

Katzenback, Barb 3.02.T-05

Katzenmeyer, Ben 4.04.T.B-01

Kaur, Gurdeep 8.03.P-We004

Kaur, Ravleen 2.04.T-01

Kaur, Sabhjeet 4.24.P-We224

Kawai, Yusuke 2.10.P-We109

Kawe, Miricara 5.07.T-02

Kay, Danielle 4.21.T-01

Kecman, Milica 2.10.P-We099

Keele, Landon 1.06.T-01, 3.06.P-Tu105

Keenan, John 4.09.T-04

Keller, Arturo 1.12.P-Tu222

Kelly, Barry 2.06.T-04

Kennedy, Chris 2.06.T-05

Kennedy, Stephanie 4.18.P-Tu276, 5.09.T-01, 5.09.T-02

Kennelly, Lucy 1.01.T-05, 2.02.P-Th256, 2.02.P-Th276, 2.02.P-Th277

Kernen, Larissa 1.07.P-We088

Kerr, Kaitlyn 2.02.P-Th260, 6.03.P-Tu023

Kerric, Anaïs 3.07.T.B-04, 3.07.T.B-06, 4.05.P-Th149

Keshavarz, Zahra 4.10.T-02

Kesic, Robert 3.08.P-Th035

Kessler, William 4.06.T-03

Key, Peter 4.23.P-Tu156, 5.02.P-We276, 5.02.P-We277, 5.02.T.A-02

Khalid, Mustajab 2.04.T-01

Khan, Bushra 2.02.T-03, 4.18.P-Tu267, 4.18.P-Tu272, 4.21.T-03, 4.23.T-04, 6.02.P-Th112

Khan, Hufsa 5.02.T.B-01

Khan, Md Gulam Musawwir 1.05.P-Th178

Khan, Nadeem 4.02.P-Tu194

KHAN, MD ANWAR HOSSAIN 4.25.T-04

Khatri, Sakshi 4.15.P-Tu181

Khazraee, Morvarid 4.02.P-Tu208

Khraibah, Abdullah 1.09.P-Tu125

Kidd, Karen 2.02.P-Th252, 2.02.P-Th263, 2.10.P-We102, 3.01.P-Th028, 4.06.P-Tu212, 4.22.P-Th219, 4.22.T-06, 5.04.P-We251, 5.04.P-We252, 5.04.P-We253, 5.04.T-04, 5.04.T-06

Kilgour, Clare 2.08.P-Tu062, 5.16.T-02

Kim, Chahun 4.03.T-05

Kim, Dong-Suk 1.07.P-We086

Kim, Euna 4.10.P-Tu004, 4.10.T-02

Kim, Eunbyeol 4.18.P-Tu282

Kim, Eunhye 1.10.P-We302, 5.09.P-Tu292

Kim, Gi Beum 4.05.P-Th143

Kim, Heejin 5.06.P-We238

Kim, Hyeon Ryeong 3.07.P-Tu047

Kim, Hyeree 5.09.P-Tu297

Kim, Jaeshin 4.18.P-Tu270, 4.22.P-Th235, 5.01.P-We062

Kim, Ji Soo 5.09.P-Tu297

Kim, Ji-Hoon 5.10.P-We137

Kim, Jihyun 3.02.T-05

Kim, Jiwan 2.01.P-Tu084

Kim, Juil 1.08.V-01, 1.08.V-02

Kim, Ki-Hyung 1.08.V-01, 1.08.V-02

Kim, Kitae 4.17.P-Tu251

Kim, Madeleine 2.14.P-We190

Kim, Minju 4.18.P-Tu282

Kim, Naeun 5.09.P-Tu292

Kim, Seunghyun 1.02.P-We244, 2.02.P-Th264

Kim, Sooyoung 5.09.P-Tu292

Kim, Taeyeon 1.10.P-We302

KIM, AEJIN 5.06.P-We239

Kimbrough, Kimani 7.10.P-Tu300

Kinart, Ella 4.24.T-04

King, Andrew Luke 4.16.V-01

King, Katherine 1.06.T-02

King, Mason D. 2.13.P-Th238, 4.17.T-03

King, Tyler 2.05.T-03

Kintzele, Emily 3.08.P-Th040

Kirk, Jane 2.12.P-We185, 2.14.T-05, 3.07.P-Tu048, 4.04.P-Th091, 4.04.P-Th100, 4.04.P-Th107, 4.04.T.A-04, 4.04.T.A-05, 4.16.T-04, 4.26.T-02

Kirkwood, Adam 2.12.P-We183

Kirkwood, Andrea 5.17.P-We264, 5.17.P-We265, 5.17.P-We266, 5.17.P-We267

Kirkwood, Ashlee 3.06.P-Tu107

Kirwa, Kipruto 8.09.T-04

Kiszka, Jeremy 3.08.T-03

Kleinmann, Joachim 5.08.P-Tu129

Kleppe, Corey 2.01.P-Tu072

Klimova, Natalia 8.02.T-06

Knäbel, Anja 2.01.P-Tu089

Knapp, Bridget 1.09.T.B-04

Knapp, Charles 2.08.P-Tu060, 6.01.P-We082

Kneeland, Jessie 5.10.P-We150

Knezevich, Nicole 5.09.P-Tu290

Knigge, Thomas 1.13.P-Tu037

Knight, Maggie 7.02.T-03

Knobloch, Emma 7.11.P-Tu305

Knockwood, Bradley 2.02.P-Th260, 2.02.P-Th268, 3.02.P-We035, 6.03.P-Tu023

Kobayashi, Norihiro 4.18.P-Tu268

Koch, Josef 5.08.P-Tu133, 5.08.P-Tu134

Koch, Kevin 2.09.T-04

Köck, Günter 4.04.P-Th091, 4.04.T.A-04

Koelmel, Jeremy 4.02.P-Tu197

Kohoutek, Jiri 4.16.V-01

KOIDE, MASASHI 3.08.P-Th043

kokushi, emiko 4.09.P-We071

Kokushi, Emiko 1.05.P-Th184, 2.02.P-Th271, 2.07.P-We054, 3.07.P-Tu058, 4.17.P-Tu235, 4.24.P-We236

Kolodziej, Edward 4.09.P-We076

Kolpin, Dana 3.06.P-Tu105, 4.23.T-05

Komane, Kagiso 4.11.P-We164

Komeyama, Soramu 1.10.P-We304

Kong, Xiang 4.05.P-Th136, 4.26.P-Th284

Kopec, Dianne 3.02.P-We032

Kopp, Darin 4.23.P-Tu149

Koprich, Olivia 2.10.P-We099

Körner, Oliver 1.13.T-05

Korunka, Kaleea 4.15.P-Tu174, 4.15.P-Tu178

Koschorreck, Jan 4.09.T-05

Kosmala-Grzechnik, Sylwia 2.02.P-Th256

Kostal, Jakub 4.09.P-We078

Kotalik, Christopher 2.01.T.A-05

Kouchaki-Penchah, Hamed 8.04.P-Tu015

Koumrouyan, Ramela 3.01.P-Th030, 3.01.T-01

Kraemer, Chloe 2.13.P-Th239

Kraemer, Susanne 2.03.P-Th013, 8.02.P-We257

Kragten, Steven 3.07.P-Tu057

Kramer, Sasha 8.04.P-Tu018

Kramer, Susanne 8.02.T-04

Kraus, Johanna 4.23.P-Tu149

Kriegel, Laurie 3.06.T-05

Krisher, Lyndsay 1.04.P-Th168

Kroder, Stefan 5.15.P-Tu168

Kroetsch, Nikki 2.08.P-Tu062, 4.17.T-03

Kroll, Kevin 1.04.P-Th168

Krueger, Henry 2.03.T-01, 2.03.T-02

Kruse, Phil 4.13.P-Th127

Kruse, Sydney 2.07.T-06

Krzykwa, Julie 1.09.T.A-01, 1.10.T-03, 1.13.T-02

Kuang, Aizhen 4.24.V-01

Kubota, Akira 2.10.P-We109

Kudalkar Gurdasani, Priyanka 5.05.P-We012

Kuecks-Winger, Haley 2.09.P-Tu032

Kuhlman, Kailey 5.09.P-Tu294

Kukolich, Stephanie 4.02.P-Tu198, 4.18.P-Tu265

Kukucka, Petr 4.16.V-01

Kulacki, Konrad 4.22.P-Th228

Kullik, Sigrun 8.02.T-02

Kumar, Nitish 8.03.P-We004

Kumarathasan, Premkumari 1.09.P-Tu125, 5.10.P-We128

Kunkel, Uwe 4.09.T-05

Kuntz, Joseph 2.12.P-We187, 5.09.P-Tu287, 7.02.P-Th208

Kunz, James 4.17.P-Tu249

Kuo, Jin-Liang 2.01.P-Tu077

Kuo, Li-Jung 4.04.P-Th099, 4.17.P-Tu246

Kurata, Osamu 4.24.P-We236

Kurelski, Devin 4.04.P-Th105

Kuzan, Timothy J, 1.08.P-We166

Kwabiah, Rebecca Ruth 2.03.P-Th005

Kwak, Ihn-Sil 5.10.P-We135, 5.10.P-We137

Kwak, Jin Il 1.07.P-We096

Kwan, Alvin 2.06.T-01

Kwan, Clarice 1.06.T-06

Kwan, Michael 3.08.T-01

Kwong, Raymond 1.04.P-Th169, 2.02.P-Th262, 2.02.T-01

L

L'Espérance, Tracey 5.09.T-06

La, Cristina 2.10.P-We121

LaBarbera, Elisabeth 2.13.P-Th243

Labelle, Justine 2.14.T-01

Laberge, Frédéric 3.02.P-We034

Labine, Brooke 4.04.P-Th093

Labine, Geriene 2.13.P-Th239

LaBine, Geriene 4.18.P-Tu261, 4.18.P-Tu262

LaBone, Elizabeth 3.02.P-We036

Labrecque, Sonia 2.14.P-We197

Lacalle, Joseph 3.03.P-Tu043

Lacroix-Durand, Charlotte 1.01.T-03

Ladokun, Olusola 5.10.P-We132

Ladouceur, Laurianne 4.23.P-Tu152

Laetz, Cathy 6.01.T-06, 6.02.P-Th109

Lafrance, Myriame 4.23.T-06

Lafreniere, Melissa 4.16.T-04

Lafrenière, Melissa 4.04.P-Th107, 4.04.T.A-05

LaFrentz, Ben 1.08.P-We166

Lagadic, Laurent 1.13.P-Tu036, 1.13.T-03, 1.13.T-05, 5.08.P-Tu129, 5.08.P-Tu132

Lagimodiere, Kim 5.07.T-05

Lahiji, Mia 4.23.P-Tu147

Lair, Stephane 2.14.T-06, 3.07.P-Tu048, 3.08.P-Th041

Lair, Stéphane 3.03.P-Tu041

Laize, Cedric 3.07.T.A-06

LakkaSandrum, Chandana 4.07.T-02

Lakshminarasimman, Narasimman 4.22.P-Th215

Lalande, Jonathan 5.10.P-We147

LaLiberty, Maren 1.12.P-Tu223

LaLone, Carlie 1.03.P-Th020

Lam, Angela 4.05.P-Th149

Lam-Colling, Jardine 2.05.P-We040

Lambert, Dominic 1.09.P-Tu121

Lambert, Jessica 7.05.P-We159, 7.05.P-We160

Lambert, Victorine 4.04.T.B-05

Lamon, Lara 4.03.T-01

Lamont, Myles 3.07.P-Tu052

Lamontagne, Julien 3.06.T-04

Lamoureux, Scott 4.16.T-04

Landa, Antonin 2.14.P-We192, 2.14.P-We193

Landis, Wayne 2.01.T.A-06, 5.16.P-We293, 5.16.P-We294, 5.16.P-We296

Landrini, Kevin 4.26.T-04

Landry, Alexander 4.02.P-Tu197

Lane, Rachael 4.17.P-Tu241, 4.17.P-Tu249, 4.17.T-04, 4.23.T-05

Laneuville, Mathieu 7.04.T-04

Langan, Laura 7.03.T-05

Langlois, Valerie 1.13.P-Tu038, 2.01.P-Tu083, 2.06.P-Th117, 2.07.P-We049, 2.09.T-05, 2.09.T-06, 4.14.P-We179, 7.04.T-01

Langlois, Valérie 2.09.T-02, 3.07.T.A-04, 7.04.T-03

Langlois, Valerie S. 2.09.T-01

Lao, Wenjian 4.05.P-Th140

Lapointe, Marie-Claude 4.04.P-Th104

Lapointe, Mathieu 4.22.P-Th233

Larivière, Dominic 2.14.P-We189

Larose, Jessica 4.21.P-Th154

Lars, Ericson 4.04.P-Th087

Larsen, Mark 2.05.P-We043

Larsen, Stefano 4.23.P-Tu149

Larson, Doug 7.04.T-02

Larue, Camille 3.06.P-Tu108, 3.06.T-05

Lashari, Tehreem 5.10.P-We126

Last, Graeme 3.06.T-06

Latendresse, Ciara 4.17.P-Tu232, 4.17.P-Tu237

Laurent, Manon 1.13.P-Tu037

Lautz, Leonie 4.03.T-01

Lavado, Ramon 1.02.P-We245, 2.01.P-Tu084, 5.02.P-We269

Lavalle, Christine 5.02.T.B-01

Lavelle, Candice 1.04.P-Th175

Lavery, Reilly 2.10.P-We099

Lavigne, Eric 5.10.P-We128

Lavoie, Isabelle 2.01.P-Tu083, 2.10.P-We116, 2.14.T-04, 4.18.P-Tu279, 4.23.P-Tu155

Lavoie, Raphael 3.07.T.A-02, 3.07.T.B-06, 3.08.P-Th042

Lavoie, Raphaël 3.01.P-Th032, 3.07.P-Tu055, 3.07.T.A-04, 3.07.T.B-02, 3.07.T.B-04, 3.08.P-Th036

Lawson, Greg 2.14.T-05, 4.26.T-02

Le, Chi 3.08.P-Th037

Le, X. Chris 1.15.P-We206

LÊ, Mathilde 2.07.T-02

Le bagousse, Marie 4.04.T.B-06

Le Faucheur, Séverine 2.14.T-02

Le Foll, Frank 2.03.P-Th004

Le Gal, Agnès 4.18.P-Tu280

Leads, Rachel 1.06.T-02

Leal-Quezada, Luz O. 4.07.V-01

Lebeau, Thierry 2.07.P-We056

LeBlanc, Hélène 4.12.P-Tu258

Lebreux Desilets, Francis 8.04.P-Tu015

Leclercq, Mickaël 1.07.P-We097

Lee, Da Yeong 1.02.P-We244

Lee, DaYeong 1.06.P-Th021

Lee, Holly 4.17.P-Tu238, 4.21.P-Th151, 4.25.T-01

Lee, Jaewoong 2.03.P-Th006

Lee, Jennifer 2.12.P-We184

Lee, Kiah 3.08.P-Th039, 3.08.T-03

Lee, Kiyoung 4.03.T-05, 5.09.P-Tu297

Lee, Linda 8.03.T-06

Lee, Moonjin 4.01.P-Th161

Lee, Sandi 3.07.P-Tu052

Lee, Woo-Mi 2.03.P-Th006

Lee, Yunseo 4.18.P-Tu282

Lee, Zhi Mei Maria 1.07.P-We093

LEE, SUJIN 5.06.P-We239

LeFauve, Matthew 5.09.P-Tu295

Lefebvre, David 1.09.P-Tu121

Lefranc, Marie 2.14.P-We188, 2.14.P-We196

Legagneux, Pierre 4.04.T.B-06

Leggatt, Margo 4.04.P-Th107, 4.04.T.A-05

Legrand, Elena 4.14.P-We177

Lehner, Bernhard 4.22.P-Th221, 4.22.P-Th229

Lehnherr, Igor 2.14.T-05, 4.26.T-02

Lei, Ying Duan 4.05.P-Th134

Lemak, Sofia 4.21.P-Th155

Lemieux, Eugenie 6.03.P-Tu025

Lemieux, Heather 1.14.P-Tu227

Lemkine, Gregory 1.07.P-We088, 1.13.T-03

Leonard, Erin 2.04.P-Tu102, 2.04.T-01, 2.04.T-04, 2.04.T-06, 2.14.P-We190, 4.04.P-Th088

Leone, David 5.09.P-Tu288, 5.09.P-Tu295

Leopold, Jörg 5.15.P-Tu168

Lépine, Maggy 2.14.P-We188

Leppanen, Matti 1.01.T-05, 2.02.P-Th276, 2.02.P-Th277

LePrell, Emily 3.02.P-We036

LeRoy, Kristine 5.18.P-We019

Lesage, Raphaëlle 4.03.T-01

Lesage, Veronique 2.14.T-06, 3.07.P-Tu048, 3.08.P-Th041

Lesage, Véronique 3.03.P-Tu041

Lescord, Gretchen 4.04.P-Th105

Leshuk, Timothy 2.06.T-04

Lessard, Avery 1.07.P-We093

Lessard, Chrystelle 4.04.P-Th102

Lessard, Karine 4.01.T-01, 4.02.P-Tu193

Letcher, Robert 1.02.P-We243, 3.01.T-01, 3.01.T-02, 3.01.T-05, 3.01.T-06, 3.08.P-Th045, 4.04.P-Th101, 4.18.P-Tu283, 5.01.T-03

Leung, Lam H 4.21.P-Th153

Levanduski, Eric 5.02.P-We286

Levasseur, Annie 8.09.P-Tu312, 8.09.T-01, 8.09.T-03

Leverett, Dean 2.03.P-Th012, 7.03.T-02

Levesque, Bailey 4.04.T.B-04

Levine, Steven 5.18.P-We023

Lewandowski, Tom 8.08.T-02

Lewis, Adam 2.09.T-03

Lewis, Ceri 2.05.P-We039, 2.07.T-05, 4.05.T-01, 4.22.P-Th225

Lewis, David 2.01.T-05, 2.02.P-Th260, 2.02.P-Th268, 6.03.P-Tu023

Lewis, Jada 3.02.T-02

Lewis, Lynn 7.02.P-Th207

Lewis, Tania 4.04.P-Th105

Li, Hui 8.03.P-We010

Li, Jingguang 5.01.P-We065

Li, Li 5.01.P-We063

Li, Qianwei 5.01.T-05

Li, Roman 1.09.T.B-02

Li, Ruosi 5.01.P-We065

Li, Simeng 4.07.P-Tu142

Li, Yanan 4.24.P-We218, 4.24.T-02

Li, Yingxi 1.09.P-Tu125

Li, Yuening 4.05.P-Th134

Li-Liao, Jenny 4.01.P-Th335

Liang, Marissa 5.08.P-Tu130

Liao, Xiangjun 4.17.P-Tu250, 4.17.T-03

Liber, Karsten 1.01.T-03, 1.01.T-05, 2.02.P-Th276, 2.02.P-Th277

Liberda, Eric 5.10.P-We129, 5.10.P-We138

Liberda Matyja, Danuta 4.15.T-02

Liechti, Silvan 4.09.T-01

Lilavois, Crystal 1.04.P-Th175

Limburg, Karin 4.26.T-05

Limouni, Wijdane 2.01.P-Tu083, 2.02.P-Th253, 4.14.P-We179

Lin, Diana 2.13.T-04, 3.07.P-Tu045, 4.15.P-Tu177, 4.17.T-01, 4.24.P-We227

Lin, Dylan 3.08.P-Th051

Lin, Haijiao 5.04.P-We249

Lin, Hsing-Chieh 2.01.P-Tu077

Lin, Junyi 4.17.P-Tu250

Lin, Tian 4.17.P-Tu231

Lin, Ting 4.24.T-05
Lin, Zhiqing 2.02.P-Th254
Lindberg, Tim 1.10.T-04
Linden, Karl 5.14.T-05
Linden, Tiffany 4.07.P-Tu139
Lindstrom, Abigail 4.15.T-02
Link- grant, Lena 6.05.P-Th204
Linley, Charlotte 1.01.T-04
Linton, Tyler 2.02.P-Th273
Lione, Danisa 2.01.P-Tu089
Little, Meghan 1.14.T-05
Liu, Chenxiao 8.02.T-04
Liu, Daniel 8.04.P-Tu015
Liu, Haizhou 4.06.P-Tu210
Liu, Jiaying 5.01.P-We065
Liu, Ju-Ling 8.02.T-06
Liu, Juhe 4.22.T-01
Liu, Lan 4.01.P-Th158, 4.23.P-Tu159, 4.25.P-Th195
Liu, Qianqian 5.09.V-01
Liu, Xiangyu 5.09.V-01
Liu, Xiaojun 4.17.P-Tu231
Liu, Yina 4.04.P-Th099
Liu, Yiwen 8.09.P-Tu313
Liu, Ziruo 4.07.T-04
Lívia Paixão, Ana 2.10.P-We104
Lizano-Fallas, Verónica 5.14.P-Th198
Llewellyn, Chris 4.15.P-Tu182
Lo, Bonnie 1.15.T-05
Lobson, Chelsea 2.08.P-Tu059
Lodge, Sam 4.25.T-01

LOFTS, STEPHEN 1.01.T-04, 1.01.T-05, 2.02.P-Th276, 2.02.P-Th277

Lohmann, Rainer 4.05.T-06, 4.09.P-We069, 4.18.P-Tu275, 4.25.P-Th194, 5.10.P-We126

Loiselle, Julie 1.09.P-Tu121

Long, Alexandra 1.09.P-Tu121

Longo, Samantha 4.13.T-06

Looney, Mary 4.14.P-We181

Lopez, Edson 4.22.T-01

Lopez, Mark Louie 2.09.P-Tu032, 2.09.T-04, 4.17.T-05

Lopez, Theresa 5.09.T-04

Lord, Heather 4.02.P-Tu199, 4.06.P-Tu211, 5.02.P-We271

Lorenz, Aly 8.08.P-Tu308

Lorrain, Marie-Josée 4.04.P-Th104

Lorsbach, Tim 5.06.T-02

Loseto, Lisa 3.03.P-Tu041, 3.07.P-Tu048, 3.08.P-Th041, 4.17.P-Tu250, 4.17.T-03

Loso, Heather 5.10.P-We140

Lott, Kevin 5.01.T-02

Lotufo, Guilherme 5.02.P-We276, 5.02.P-We277

Lovallo, Maria 6.05.T-03

Løvik, Amund N. 5.15.P-Tu169

Lovy, Jan 1.06.T-04

Lowrey-Dufour, Christopher 1.03.T-01, 1.09.P-Tu119

Lu, Zhe 3.01.P-Th030, 3.07.T.B-03, 3.08.P-Th042, 4.24.P-We228

Lucotte, Marc 4.23.P-Tu152

Ludwig, James 3.08.T-06

Luek, Andreas 1.15.P-We206

Luera, Eric 4.05.P-Th141, 4.05.P-Th142

Lukose, Jijo 4.24.P-We221

Luna-Díaz, Jennifer M. 4.07.V-01

Lundgren, Rylan 4.25.T-02

Lundin, Jessica 6.02.P-Th109

Lundqvist, Johan 1.01.T-06, 1.09.T.B-06

Lunsman, Ph. D., Tamara 2.03.P-Th014

Luo, Kathleen 5.17.P-We260

Luthi-Maire, Adèle 4.04.P-Th103, 4.24.P-We224

Lydy, Michael 2.01.P-Tu076, 2.10.P-We121, 7.10.P-Tu299

Lydy, Tory 5.02.P-We283

Lynch, Iseult 5.02.T.A-05

Lynch, Jeniffer 1.15.P-We202

Lynn, Scott 1.13.P-Tu034, 1.13.T-01, 5.06.P-We237

Lyon, Delina 1.13.P-Tu039

Lyu, Bing 5.01.P-We065

M

M Riveron, Jacob 5.15.P-Tu171

M. Borghese, Michael 5.10.P-We128

M.M. NAKAYAMA, Shouta 4.23.P-Tu160

Macairan, Jun-Ray 4.15.P-Tu172

MacDonald, Lauren 2.01.T-05, 2.02.P-Th260, 2.02.P-Th268, 6.03.P-Tu023

Macfarlane, Gemma 4.04.P-Th107

Machimbirike, Vimbai Irene 2.03.P-Th005

Machimbirike, Vimbai 1.04.P-Th173

Maclean, Bruce 2.06.T-02

MacLeod, Haley 2.12.P-We183

MacLeod, Matthew 4.04.P-Th086, 4.04.P-Th106

MacNeil, Danielle 3.01.T-05

MacPhee, Shannon 3.07.P-Tu048

Madsen, Anders L. 2.01.P-Tu078, 4.23.T-02

Magee, James 4.15.P-Tu188

Maggio, Stephanie 5.09.P-Tu288, 6.01.P-We081

Magnus, Rebecca 3.07.T.B-01

Magnuson, Jason 1.06.P-Th022, 1.06.T-01, 5.02.P-We281, 5.02.T.A-03

Maguire, Steven 7.08.P-Tu137

Mahabir, Pria 1.13.T-04, 2.03.P-Th017, 3.07.P-Tu057

Mahalekam, Dhananjalee 4.08.P-We030

Mahoney, Anna 5.04.T-03

Mahovsky, Thomas 4.02.P-Tu206

Maisonneuve, France 3.07.P-Tu051

Majoris, Evelyn 4.24.P-We230

Majury, Anna 8.02.T-05

Malala Irugal Bandaralage, Susari 3.07.T.B-01

Maldonado, Estrella 1.04.P-Th174, 2.05.T-01, 4.06.P-Tu217

Maldonado Rodriguez, Ambar 4.04.T.B-05

Maldonado Rodriguez, Ámbar 3.08.T-03

Malec, Ron 4.02.P-Tu208

Malfavon, Mario 4.05.P-Th139, 6.03.P-Tu028

Malik, Sabine 2.01.T.B-06, 7.02.P-Th206

Malik-Vidal, Sara 5.04.P-We249

Malina, Natalia 4.09.P-We068

Mallory, Mark 2.07.P-We055, 4.26.P-Th281

Maloney, Erin 1.10.T-01

Maltby, Lorraine 5.15.P-Tu166

Manabe, Sota 4.15.P-Tu189

Manahan, Kessmar 2.06.T-04

Mandava, Geeta 1.01.T-06

Manfrin, Alessandro 2.01.P-Tu089

Manjarres Hernandez, Yeri Luz 1.05.P-Th185

Manliclic, Adrian Deil 1.06.T-02

Mann, Gary 1.01.P-Tu012, 2.12.P-We186

Mano, Hiroyuki 2.03.P-Th016

Mansfeldt, Cresten 4.10.T-04, 4.22.P-Th237, 5.14.T-05

Marchal, Louis 4.23.P-Tu157

Marchand, Hugo 1.05.T-04, 1.05.T-06, 1.09.P-Tu120, 1.09.T.A-05, 4.05.P-Th137, 4.05.T-03, 4.17.P-Tu240

Marek, Rachel 4.05.P-Th132, 4.05.P-Th133, 4.21.T-05, 4.22.T-03

Marestay, Paloma 4.02.P-Tu193

Marginson, Holly 2.14.T-01

Mariani, Daniela 3.07.T.A-05

Mariz, Célio F. 1.06.T-01

Mariz Jr, Célio 1.06.P-Th022

Markey, Kristan 1.13.P-Tu034

Marko, Olivia 4.24.P-We220

Marlatt, Vicki 2.09.T-04, 7.04.T-01

Marriott, Amy 1.13.T-02

Marshall, Aylish 1.05.T-04, 1.09.P-Tu120, 1.09.T.A-05

Marshall, Jermey 2.02.P-Th252

Martin, Jonathan 4.05.P-Th134

Martin, Nadia 6.01.P-We080

Martin, Sidney 3.07.V-01

Martineau, Christine 2.06.P-Th116

Martinez, Nicole 4.13.P-Th126, 4.13.P-Th127, 4.13.T-05

Martinez-Guitarte, Jose-Luis 2.01.P-Tu074, 2.02.P-Th249

Martinko, Carolyn 2.07.T-01

Martins, Samantha 2.01.P-Tu078, 4.23.T-02

Marton, John 5.11.P-Tu162, 5.11.P-Tu164

Martucci, Maria Elvira Poleti 4.11.P-We162

Martyniuk, Christopher 5.02.P-We282

Marvin, Chris 4.07.T-01, 4.12.P-Tu254

Masindi, Vhahangwele 4.11.P-We164

Masís-Mora, Mario 5.14.P-Th198

Mason, Julia 2.07.P-We045

Masoner, Jason 4.23.T-05

Masoner, Jason R. 3.06.P-Tu105

Masse, Jacynthe 4.23.P-Tu152

Massoud, Rana 1.06.P-Th024

Masullo, Cara 3.01.P-Th031

Mateev, Dragomir 4.04.T.A-03

Mathew, Juviya 4.15.P-Tu185

Mathew, Miriam 4.12.P-Tu257

Mathews, Teresa 1.06.P-Th024, 1.06.P-Th027

Mathiron, Anthony 2.01.P-Tu068

Mathis, Michael 1.13.P-Tu034

Mathye, Mathlodi 4.11.P-We164

Matohi, Rose-Gaëlle 1.07.P-We097

Mats, Tysklind 4.04.P-Th087

Matson, Cole 2.01.P-Tu084, 6.01.T-02

Matsukami, Hidenori 4.02.P-Tu203, 4.22.P-Th226

Matsumoto, Mizuki 2.10.P-We118

Matsuura, Elizabeth 1.12.P-Tu223

Matthews, Cory 3.08.T-03, 4.04.T.B-05

Matthews, Ty 3.08.P-Th037

Maul, Jonathan 3.07.P-Tu057

Maunder, Richard 1.13.P-Tu036

Maurer-Jones, Melissa 4.17.T-02

May, Darran 4.04.P-Th092

Mayasich, Sally 1.13.P-Tu034

Maybruck, Vanessa 4.22.P-Th237, 5.14.T-05

Mayer, Ludovic 4.06.T-06

Mazur, Emily 6.01.P-We080

Mbagwu, Chidi 4.04.T.B-01

McAlpine, Donald F. 3.02.P-We035

McArdle, Margaret (Meg) 4.24.P-We230

McCallum, Kamryn 5.07.P-We165

McCarthy, Christopher 5.02.P-We272, 5.02.P-We283, 5.02.T.B-06

McCartney, Mitchell 4.19.T-06

McCarty, Lynn 2.01.T.A-01

McClain, Craig 4.07.P-Tu144

McClelland, Christine 2.06.T-02

McConachie, Anastasia 2.13.T-02

McCooeye, Chris 4.02.P-Tu204

McCosh, Rick 1.07.P-We093

McCourt, James 2.06.P-Th115

McCoy, Sarah 5.01.P-We064, 5.05.P-We014, 5.05.P-We016

McDermott, Sydney 4.07.P-Tu144

McDonald, Emma 4.02.T-01

McDonough, Carrie 3.07.P-Tu045, 4.19.T-02

McGeer, Jim 2.04.T-01

McGrail, Dayton 4.24.P-We218

Mcgrath, Joy 5.09.P-Tu288, 6.01.P-We081

McGregor, Alison 4.01.T-04

McGregor, Erin 4.23.T-03

McGregor, Maura 3.08.P-Th050

McGruer, Victoria 2.05.T-06

McGuire-Diemer, Karen 4.10.P-Tu003

McIntyre, Jenifer 2.13.P-Th245, 2.13.T-02, 3.08.T-04, 4.26.T-01

McKechnie, Jennifer 5.09.P-Tu288

McKenna, Sabrina 2.02.P-Th266

McKenney, Heather 8.08.P-Tu308, 8.08.T-02, 8.08.T-04

McKenzie, Emily 3.02.T-05

McKeown, Ryan 5.14.T-05

McKercher, Levi J. 2.13.P-Th246

McKinney, Melissa 3.01.T-01, 3.01.T-05, 3.08.T-03, 4.04.T.B-04, 4.04.T.B-05

McLachlan, Dawson 4.21.P-Th148

McLatchie, Madi 3.03.P-Tu042

McLaughlin, Sean 2.07.P-We045, 5.05.P-We013

McLay, Emma 4.25.T-06

McLean, Cassie 4.23.T-06

McLoughlin, Colleen 8.08.T-02

McMahan, Colleen 2.13.P-Th242

McMahon, Kiersten 1.07.P-We095

McMartin, Dena 2.06.P-Th119

McMartin, Dena W. 2.06.P-Th113

McMinn, Madison 4.17.P-Tu244

McNabney, David 1.02.P-We246, 2.10.P-We117, 2.14.P-We190

McNeel, Kevin 4.04.P-Th092

McNett, Debra 4.04.T.A-03

McPhail, Gretchen 4.26.P-Th281

McPherson, Alyss 4.01.P-Th157, 4.06.T-02

McQueen, Rachel 4.02.P-Tu206

McRobie, Nikki 5.07.T-02, 7.07.T-03

McTavish, Kathleen 1.01.T-03

McVean, Kirsten 3.06.T-06

McWillie, Maycie 5.04.P-We253

Mebane, Chris 1.15.P-We205, 1.15.T-03, 2.05.T-03

Mebane, Christopher A. 2.14.T-03

Mebane, Christopher 1.15.P-We200, 1.15.T-06, 7.12.T-04

Meco, Marjol 2.13.T-06

Mederer, Bernadette 1.09.P-Tu126

Meguriya, Noriyuki 5.01.P-We062

Mehalic, Seth 8.08.T-03

Mehdi, Qaim 2.07.T-03, 3.02.P-We038

Mehinto, Alvine 2.05.T-06, 4.15.T-05

Mehla, Sunidhi Devi 8.03.P-We006

Mehta, Jyotigna 5.10.P-We145

Mélançon, Vincent 3.07.V-01

Meleder, Vona 2.07.P-We056

Mellgren, Chloe 4.17.T-02

Melnick, Mikayla 6.01.P-We082

Melymuk, Lisa 4.16.V-01

Memmel, Johann 2.04.T-04, 2.14.P-We190

Mena-Giraldo, Pedro 2.03.P-Th007, 4.15.P-Tu172, 4.15.T-06

Menden-Deuer, Susanne 4.09.P-We069

Mendez, Miguel 2.13.T-04, 3.07.P-Tu045, 5.04.T-05

Méndez, Miguel 5.04.T-03

Méndez Loeza, Iván 2.01.P-Tu081

Mendoza Lera, Clara 2.01.P-Tu089

Mendoza-Caro, Sindy 5.10.P-We141

Menéndez-Pedriza, Albert 1.04.P-Th166

Mengeling, Brenda 4.21.P-Th147

Mennigen, Jan 1.09.P-Tu125, 7.04.T-01

Mensah, Jeremiah 7.08.P-Tu136

Mentzel, Sophie 2.01.P-Tu078, 4.23.T-02

Meppelink, Shannon 4.23.T-05

Meraldi, Verena 4.16.V-01

Mercado Páez, Jessica 1.07.P-We092

Mergler, Donna 2.12.P-We184

Merlo, Ana 7.04.V-01

Merrington, Graham 1.01.P-Tu010, 1.01.T-04, 1.01.T-05, 2.02.P-Th276, 2.02.P-Th277, 2.03.P-Th012, 5.14.T-03, 7.03.T-02

Meruva, Naren 4.01.P-Th163, 4.02.P-Tu201, 4.07.P-Tu145, 4.21.P-Th154

Mesarick, Giuliana 3.07.P-Tu054

Messerman, Arianne 2.02.P-Th274

Messerschmidt, Cristin 4.12.P-Tu257

Metcalfe, Chris D. 5.14.P-Th197

Mettler, Valentin 2.06.P-Th117, 2.07.P-We049

Meurice, Naomi 8.05.P-We215

Meyer, Carolyn 3.04.P-We309

Meyer, Danielle 2.02.P-Th251, 5.02.T.A-06

Meyer, Fallon 4.04.P-Th098

Meyer-Jacob, Carsten 2.01.T.B-02

Meyers, Alyssa 5.02.T.A-06

Mhlambi, Zamansele 4.11.P-We164

Micali Nuvoloni, Felipe 2.10.P-We104, 3.07.T.A-05

Michael, Emma 2.10.P-We125

Michaelson, Lizy 4.24.T-05

Michaud, Robert 3.03.P-Tu041

Michaud-Valcourt, Julien 1.01.T-03, 2.14.P-We195

Middlebrooks, Camryn 4.04.P-Th098, 4.04.T.B-01

Mihaich, Ellen 4.24.P-We230, 7.12.T-02

Mikkelsen, Bjarni 3.08.T-03

Miller, Allisyn 1.12.P-Tu221

Miller, Ezra 2.13.T-04, 3.07.P-Tu045, 4.21.P-Th147, 4.21.T-06, 5.04.T-03

Miller, Gillian Z. 4.24.P-We218

Miller, Janet L. 2.14.T-03

Miller, Jason 4.04.T.A-05

Miller, Lizzie 4.24.P-We229

Miller, Logan 4.07.P-Tu139, 4.27.T-03, 5.17.P-We260

Miller, Melissa 3.02.T-02

Miller, Tara 1.01.P-Tu010, 1.13.T-05

Milligan-McClellan, Kat 6.05.T-03

Milusich, Eve 5.07.T-04

Mina, Odette 4.06.P-Tu215

Mingo, Valentin 1.13.T-05

Minic, Zoran 1.09.P-Tu125

Mintram, Katie 5.08.P-Tu129

Mintzer, Vanessa 3.07.P-Tu050

Mir, Ishfaq showket 2.06.P-Th117, 2.07.P-We049

Mirabzadeh-Ardakani, Ali 2.09.T-03

Miraly, Hadis 4.26.T-05, 7.10.P-Tu299

Miranda-López, Libnny Citlalli 4.15.P-Tu180

Mitchell, Carl 4.04.P-Th107, 4.04.T.A-05

Mitchelmore, Carys 2.01.T.B-06, 2.03.P-Th002, 2.03.T-06, 5.14.T-06, 7.12.T-03

Mithal, Leena B. 5.04.T-01

Mitrovic, Dejana 2.02.P-Th261

Mitta, Guillaume 1.07.P-We097

Mittal, Krittika 1.05.P-Th180, 1.05.P-Th183, 1.05.T-05, 1.09.P-Tu120, 1.09.T.A-05, 1.09.T.A-06, 1.09.T.B-03, 8.08.P-Tu309

Mizutani, Satoshi 4.02.P-Tu203

Moe, Annelisa E. 8.05.P-We215

Moe, Jannicke 2.01.P-Tu078, 4.23.T-02, 5.16.P-We290, 5.16.P-We291

Mohamed-Benhammou, Ahlam 2.01.P-Tu074

Mohamed-Benhamu, Ahlam 2.02.P-Th249

Mohamedali, Sharhabil 1.02.V-01

Mohammadi, Hana 8.09.T-05

Mohs, Tristan 4.17.P-Tu241

Moin Kenary, Ariana 1.03.P-Th019

Moingt, Matthieu 4.23.P-Tu152

Molaro, Jenna 5.02.T.B-04, 5.10.P-We149

Moloney, Molly 1.15.T-03

Monroe, Isabelle 2.08.P-Tu064, 2.08.P-Tu065, 2.08.P-Tu066

Monsinjon, Tiphaine 1.13.P-Tu037

Montabon, Lillian 4.05.P-Th132, 4.05.P-Th133

Monteiro, Marta 1.13.P-Tu038

Montemayor, Beta 1.09.T.B-02

Montero-Serrano, Jean-Carlos 4.04.T.A-01

Montez-Rath, Maria 4.08.P-We030

Montgomery, Dawn 4.13.P-Th126

Montoya, Ada Camila 2.13.P-Th246

Montrose, Luke 1.07.P-We093

Moody, Adam 2.02.P-Th274, 4.17.P-Tu247

Moon, Eunbi 2.03.P-Th006

Moon, Hyo-Bang 3.07.P-Tu047, 4.01.P-Th161

Moon, Yuseok 1.08.V-01, 1.08.V-02

Moore, David 5.02.P-We276, 5.02.P-We277

Moore, Dwayne 3.02.T-04, 5.15.P-Tu169, 5.18.P-We023

Moore, Jocelyn 1.09.P-Tu121

Moore, Joel 4.06.P-Tu216

Moores, Audrey 4.07.T-04, 4.15.T-01, 7.07.T-01

Moraes Utsunomiya, Heidi Samantha 2.01.P-Tu086

Moragrega, Emma 1.04.P-Th167

Morales, Libby 5.02.T.B-05

Moran, Kelly 2.13.T-04, 4.12.P-Tu253, 4.24.P-We227

Moran, Patrick 2.02.P-Th279, 5.09.P-Tu296

Morash, Michael G 4.26.T-06

Moreau, Lucas 8.04.P-Tu015

Moreau, Marjory 4.03.T-01

Morello-Frosch, Rachel 5.02.P-We270

Moreno, Paalo 8.04.P-Tu017

Moreno-Bayona, Alejandra 3.06.T-05

Morgan, Amanda 1.13.P-Tu034

Morgan, Ashley 3.07.P-Tu056

Morgan, Jane 2.04.T-01

Morgan, Lyssa 8.05.P-We216

Morgan, Rachel 3.07.V-01

Mori, Ayaha 4.15.P-Tu189

Moriarity, Robert 5.10.P-We129, 5.10.P-We138

Morozova, Arina 7.10.P-Tu300

Morrill, Andre 3.07.T.B-03

Morris, Jeffrey 2.10.P-We107, 6.02.P-Th108

Morrissey, Christy 1.02.P-We240, 3.01.T-03, 3.07.T.A-03, 3.08.P-Th035, 3.08.P-Th053, 4.23.T-01, 5.01.T-03

Mortensen, Spencer 5.18.P-We021

Mos, Lizzy 3.07.P-Tu053

Mosch, Nora 1.02.T-02, 2.10.P-We111, 2.10.P-We112

Moßgraber, Annabelle 2.01.P-Tu089

Motoyama, Yuto 4.15.P-Tu189

Motti, Cherie 3.03.P-Tu042

Mouchet, Florence 8.02.T-03

Mounicou, Sandra 2.14.T-02

Moura, Thomas 8.02.T-03

Moura Félix, Laura 2.01.P-Tu086

Muehlbauer, Jeffrey 4.23.P-Tu149

Mueller, Kristin 1.01.T-03, 1.05.P-Th185, 1.05.T-06, 2.14.P-We189

Mueller, Sean 8.09.T-04

Muench, Douglas 2.06.P-Th116, 2.06.P-Th119

Muhammad Arfan, Hafiz 5.04.P-We249

Muir, Derek C.G. 4.24.P-We228

Muir, Derek 4.04.P-Th091, 4.04.P-Th100, 4.04.T.A-04, 4.04.T.A-05, 4.04.T.B-04, 7.10.P-Tu301

Muirhead, Richard 8.01.T-03

Mukohyama, Yuli 2.08.P-Tu063

Mulholland, Margaret 4.27.T-02

Muller, Erik 5.08.P-Tu129

Müller, Peter 2.01.P-Tu089

Müller-Schüssele, Stefanie 2.01.P-Tu089

Mulye, Hemendra 4.13.T-06

Mumford, Kevin 2.06.T-05, 6.01.P-We082

Mumtaz, Mehvish 1.06.T-02, 1.06.T-03

Mundle, Scott 4.15.P-Tu181

Mundy, Ian 4.02.P-Tu202, 4.17.T-02, 5.01.T-02

Mundy, Kylara 7.11.P-Tu304

Mundy, Lukas 1.02.P-We240, 2.06.P-Th118, 2.06.T-02, 3.07.T.B-01

Munezero, Anne 4.04.P-Th093

Munoz, Gabriel 4.01.T-01, 4.02.P-Tu193, 4.05.T-03, 4.22.T-04

Muñoz-Carpena, Rafael 5.11.P-Tu163

Munson, Amelia 3.07.T.A-06

Murillo-Gelvez, Jimmy 4.07.T-02

Murphy, Cheryl 1.06.P-Th027, 1.06.T-02, 1.06.T-03, 5.08.P-Tu131, 8.03.P-We010

Murphy, Jennifer 4.25.T-05

Murphy, M. 5.07.T-01

Murphy, Margaret 3.07.T.B-05

Murray, Erin 1.15.P-We205, 1.15.T-03, 1.15.T-06, 2.05.T-03

Murray, Katie 7.03.T-01

Musetta-Lambert, Jordan 2.01.P-Tu069, 2.05.P-We040

Musgrave, Christopher 1.12.P-Tu224

Musiani, Marco 4.04.P-Th105

Myszkal, Gabrielle 4.16.T-04

N

Nabgui, Abderrahmane 3.06.P-Tu108, 3.06.T-05

NABGUI, Abderrahmane 3.06.P-Tu110

Nader, Sadeya 4.25.T-05

Naderi, Mohammad 2.02.T-01

Nagano, Kazuya 4.15.P-Tu189

Nagao, Akiko 5.04.P-We247

Nagpal, Anika 4.09.P-We074

Nair, Pranav 4.07.T-05

Naito, Wataru 2.03.P-Th016, 4.24.P-We223, 5.01.P-We062

NAITO, WATARU 5.10.P-We146

Nakagawa, Phoenix 3.06.T-01

Nakayama, Kei 4.17.P-Tu234, 4.17.P-Tu235, 4.24.P-We236

Nakayama, Shouta 3.08.P-Th043

Namba, Noriaki 5.04.P-We247

Narayanan, Raghav 4.12.P-Tu257

Narizzano, Allison 5.02.P-We272

Nash, Mackenzie 1.05.P-Th181, 1.05.P-Th182, 1.05.T-03, 1.06.P-Th026, 1.06.T-05, 4.19.P-We207

Nason, Sara 2.07.P-We047, 4.02.P-Tu197, 4.06.T-03, 4.21.T-04, 5.17.P-We261, 8.03.P-We009

Navarro-Martin, Laia 1.04.P-Th166, 1.04.P-Th167, 1.13.P-Tu038

Nazdrajić, Emir 4.21.P-Th148, 5.17.P-We263

Nazemof, Nazila 1.09.P-Tu125

Ndlela, Luyanda 4.18.V-02

Nedrich, Sara 2.02.P-Th258, 2.02.T-06

Needham, Katie 7.08.P-Tu136

Neglia, Julia 5.04.P-We252

Neill, Caitlin 5.17.P-We258

Nelson, Isabella 4.05.P-Th135, 7.03.T-01

Nelson, Isabelle 4.04.P-Th092, 4.04.T.A-06

Nelson, Jasen 5.16.P-We293

Neraasen, Anwyn 1.03.P-Th019

Neumann, Norman 4.27.T-06

Newman, Lee 1.04.P-Th168

Ng, Carla 5.01.T-05, 7.05.P-We158

Ngew, Estee 1.08.P-We168

Nguyen, Huy 4.24.T-02

Nguyen, Le Thanh Dien 4.02.P-Tu206

Nguyen, Minh 4.22.P-Th237

Nguyen, Nhi 2.02.T-01

Nguyen, van Xuan 8.02.T-03

Nicell, Jim 4.22.P-Th221, 4.22.P-Th229

Nicholas, Eugene 5.07.P-We165, 5.07.T-03

Nicholas, Kailey Karahkwinéhtha 5.07.T-03

Nicholas, Kailey 5.07.P-We165

Nicholas, Mary 5.07.P-We165, 5.07.T-03

Nichols, Elizabeth 3.08.P-Th034, 4.05.T-05, 5.02.T.A-01

Nicklisch, Sascha 1.07.P-We090

Nickols, Kerry J. 8.05.P-We215

Nielsen, Kristin 2.01.P-Tu071, 2.07.P-We057, 4.04.P-Th092, 4.04.T.A-06, 4.22.P-Th217, 5.17.P-We258

Niepukolie, Nipu 1.09.P-Tu125

Niesen, Meghann 5.08.P-Tu130

Nikiforov, Vladimir 4.04.T.A-03

Nilsen, Frannie 5.02.T.A-04

Nimako, Collins 4.23.P-Tu160

Nipen, Maja 4.04.T.A-03

Niro, Natalie 8.02.T-01

Nisbet, Roger 1.06.P-Th027, 1.06.T-02, 1.06.T-03, 5.08.P-Tu131

Nishimwe, Kizito 5.09.P-Tu294

Nishioka, Sakiko 2.07.P-We052

Nistorescu, Irina 4.25.T-03, 4.25.T-05

Niyogi, Som 1.04.P-Th171, 1.15.T-04, 2.02.P-Th277

Nödler, Karsten 4.09.T-05

Noel, Marie 3.07.P-Tu048, 3.08.P-Th041

Noernberg, Tommy 4.14.P-We178

Nolan, Lily 3.06.P-Tu107

Nolasco Banegas, Maria 4.24.P-We222

Nombré, Yannick Arnold 4.23.P-Tu155

Nomiyama, Kei 2.10.P-We109

Nong, Andy 1.09.P-Tu122, 4.03.T-03

Norberto Weber, Luiz 2.10.P-We104

Norena-Barroso, Elsa 2.02.P-Th259, 4.18.P-Tu269, 5.09.P-Tu298, 7.05.P-We157

Norouzi, Samira 4.01.P-Th159, 5.06.T-05

Norris, Emmet 4.18.P-Tu264

Nowack, Bernd 3.06.P-Tu108

Nowak, Karolina 4.10.T-06, 4.24.P-We231, 4.26.T-03

Nunziangeli, Luisa 5.02.T.A-05

Nur, Gokce AYAZ 5.09.P-Tu292

Nussbaum, Benjamin 2.01.P-Tu085

Nwojo, Dr. Princely Enyinnaya 4.18.V-01

Nyambego, Hesbon 1.10.T-04

Nyarko, Laurinda 4.09.T-04, 4.22.P-Th227

Nygren, Olle 4.04.P-Th087

Nykamp, Natalie 2.04.P-Tu102, 2.04.T-04

Nyoni, Hlengilizwe 4.06.P-Tu215

O

O, Emily 2.07.P-We050

O'Brien, Jason 1.02.P-We240, 1.05.T-01, 1.09.T.B-01

O'Connor, Constance 2.12.P-We183

O'Donnell, Lynne 8.02.P-We256

O'Driscoll, Nelson 4.26.P-Th281, 4.26.P-Th283

O'Malley, Kelly 4.05.P-Th135, 4.05.P-Th145, 4.10.T-03

O'Malley, Michelle 4.06.P-Tu210

Oates, Theodore 2.10.P-We110

Obal, Terry 4.05.T-04

Öberg, Gunilla 5.07.T-01

Obianwuna, Uchechukwu 3.04.V-01

Obregon-Alvarez, Dasiel 2.06.P-Th113

Ochoa, Jael 4.17.P-Tu233

Oda, Yusuke 2.03.P-Th006, 4.24.P-We232, 5.04.P-We247

ODAYA, Yoshiya 3.08.P-Th043

Oehrle, Stuart 5.10.P-We152

OGASAWARA, Kohei 3.08.P-Th043

Ogbomida, Emmanuel 4.23.V-01

Ogbomida, Emmanuel Temiotan 2.02.V-01

Ogudo, Marcellinus 4.27.P-We300

Ogunlaja, Aemere 5.10.P-We132

Ogunlaja, Olumuyiwa 5.10.P-We131, 5.10.P-We132

Ogunseitan, Oladele 8.08.T-03

Ogura, Kyoko 2.10.P-We109

Oh, Jenny 4.01.T-04, 4.05.P-Th134, 4.19.P-We210

Oh, Jin-su 4.05.P-Th143

Oh, Seok-Young 6.03.P-Tu020

OHANUSI, IRENE 6.03.P-Tu026

Ohno, Koichi 5.04.P-We247

Ojeda, Nadezda 6.03.P-Tu028

Ojimgba, Onwuchekwa 3.06.P-Tu106, 6.05.T-05

Okafor, Chidinma Peace 6.05.P-Th199

Okafor, Emmanuel 3.06.P-Tu106, 6.05.T-05

Okalanwa, Chima 2.02.P-Th254

Okazaki, Yukiyo 1.10.P-We304, 2.10.P-We120

Okeke, Patricia Uchenna 2.02.V-01, 4.23.V-01

Okeme, Joseph 4.01.P-Th157, 4.01.P-Th335, 4.01.T-06, 4.05.P-Th149, 4.06.T-02, 4.21.P-Th150

Okoro, Ikwuakonam George 6.05.P-Th203

Olatunji, Olatunde 4.18.V-02

Oleforuh-Okoleh, Vivian 3.04.V-01

Olenyi, Tobias 5.06.T-02

Olivares, Christopher 4.10.T-02, 8.05.P-We216

Oliveira, Mariana 4.11.P-We162

Oliveira Pereira, Erico 1.09.P-Tu128, 4.13.P-Th125, 5.02.P-We282

Oliver-Olsen, Caitlin 4.02.T-01

Olivier, Stéphanie 1.13.P-Tu037

Oloye, Femi 5.03.P-We212

Olson, Connor 4.10.T-02

Omagamre, Eguono 2.07.T-04, 3.03.P-Tu044

Omagamre, Wayne 4.22.P-Th236, 5.02.P-We287, 6.05.P-Th204

Omana, Daniel 4.12.P-Tu256, 4.18.P-Tu263

Omer, Meredith J. 3.08.P-Th050

Omotola, Elizabeth 4.18.V-02

Onireti, Oluwatoyin B. 1.04.P-Th173

Onireti, Oluwatoyin Bukunmi 2.03.P-Th005

Ono, Junko 4.22.P-Th226

Onucki, Kaylee 4.18.P-Tu274

Opoku, Richard Boadu 5.10.P-We133

Oppong, Vivian Benefoa 4.23.P-Tu159

Orefice, Joseph 4.06.T-03

Orelo, Barbara 3.03.P-Tu043

Organtini, Kari 4.02.P-Tu201, 4.07.P-Tu145

Orihel, Diane 2.06.T-05, 3.02.T-05, 4.17.P-Tu250, 6.01.P-We082

Ormeci, Banu 1.14.T-03, 1.14.T-04

Ortego, Lisa 5.05.P-We011, 5.05.P-We012

Ortiz-Montalvo, Diana 4.15.T-02

Orton, Frances 2.01.T.B-03, 3.07.T.A-06

Osei-Akyeampong, Prince 7.08.P-Tu136

Osentowski, Raegan 4.22.P-Th217, 5.17.P-We258

Oshima, Yuji 2.10.P-We118, 7.04.T-05

Oskarsson, Agneta 1.01.T-06, 1.09.T.B-06

Ospital, Louisa 8.01.T-01

Ostermann, Elizabeth 2.02.P-Th270, 2.03.T-02, 5.01.P-We066

Ott, Amelie 1.09.T.B-02, 5.09.T-02

Oullet, Felix 4.17.T-03

Owens, Alek M. 5.03.P-We212

Owens, Ed 2.06.P-Th115

P

P. Chivers, Douglas 2.10.P-We110

Pace, Clare 5.02.P-We270

Pacheco-Castro, Roger 7.05.P-We157

Paciello, Sofia 1.07.P-We085, 3.08.T-01

Paddock, Brett 4.07.T-01, 4.12.P-Tu254

Padgett, Zachary 2.01.P-Tu092

Page-Lariviere, Florence 1.09.P-Tu120, 4.03.P-Th164

Pagé-Larivière, Florence 1.09.P-Tu121, 1.09.T.A-05

Paige Powell, Paige Powell 3.08.P-Th052

Palace, Vince 2.01.P-Tu071, 2.02.P-Th252, 2.06.P-Th115, 2.09.P-Tu033, 6.03.P-Tu024

Panchacharam, Iyngaran 8.09.T-02

Pandelides, Zacharias 5.02.P-We268, 5.02.P-We284, 5.02.T.A-03, 5.02.T.B-02

Pandey, Anushka 4.22.T-05

Panko, Julie 4.18.P-Tu276

Panter, Grace 1.13.P-Tu036

Papavasileiou, Konstantinos 5.02.T.A-05

Papazian, Stefano 4.05.P-Th134

Papke, Jillian 2.01.T.B-01, 3.08.P-Th053

Paquet, Benjamin 2.10.P-We115

Paquet, Nathalie 1.01.T-01

Paquin, Jean 7.04.T-04

Paquin, John 5.09.P-Tu288

PARDON, Patrick 3.08.P-Th044

Paredes, Daniel 5.15.P-Tu166

Parent, Lise 4.23.P-Tu155

Parga Martinez, Karla 4.15.P-Tu173, 4.24.P-We219

Paris, Claire 2.01.T.B-04

Paris, Louise-Emmanuelle 4.13.T-02

Park, Bradley 2.08.P-Tu061

Park, Jordan 2.07.P-We044

Park, Kiyun 5.10.P-We135, 5.10.P-We137

Park, Minseok 8.06.P-Th186

Park, Yujin 5.09.P-Tu292

Parker, Lacey 7.02.P-Th208

Parker, Rina 4.13.T-01

Parker, Samuel 4.14.P-We177

Parker, Wayne 4.22.P-Th215, 4.22.P-Th216

Parnis, J. Mark 5.14.P-Th197

Parrott, Joanne 2.06.P-Th120

Parry, Emily 4.07.P-Tu140

Pasparakis, Christina 2.01.T.B-04, 2.02.P-Th278, 2.03.P-Th001, 3.08.P-Th049, 3.08.P-Th051

Pasqualetti, Sarah 6.05.T-03

pastore, isabella 4.01.P-Th335

Patabandige, Dinuka 2.01.P-Tu092

PATEKAR, Sonali 8.04.P-Tu016

Patel, Alpeshkumar 4.02.P-Tu194

Patel, Jay 2.06.T-04

Patel, Rishi 6.01.T-03

Paterson, Kayli 2.13.T-04, 4.15.P-Tu177, 4.17.T-01, 4.24.P-We227

Patnaude, Michael 5.05.P-We015

Patten, Kessen 1.09.P-Tu125

Patterson, Allison 3.01.T-06

Pauli, Bruce 2.06.P-Th118, 3.07.T.B-01

Pautler, Brent 4.05.P-Th129, 4.05.T-05, 6.01.T-04

Pavord, Lillian 3.08.T-04

Pawlowicz, Richard 2.07.P-We048

Payne, Katie 3.03.P-Tu043

Payne, Sarah Jane 4.07.T-06, 8.02.T-01

Pearl, Chris 3.02.T-01

Pearson, Ayla 5.16.P-We298

Peaslee, Graham 4.02.T-03, 4.06.T-04

Pecquet (Willis), Alison 5.10.P-We145

Pedinotti-Castelle, Marianne 8.04.P-Tu017

Peebles, David 4.04.T.B-01

Peele, Cheri 8.08.T-02

Pegoraro, Adrian 4.15.P-Tu190

Pelletier, Alex 2.01.T.B-01

Pelletier, Guillaume 1.09.P-Tu121

Pelletier, Rick 4.14.P-We178

Pendelton, Tilda 4.06.P-Tu218

Peng, Hui 1.13.P-Tu040, 2.13.T-03, 3.03.P-Tu041, 4.01.P-Th156, 4.01.T-04, 4.01.T-05, 4.07.P-Tu141, 4.07.P-Tu142, 4.07.T-03, 4.07.T-05, 4.08.P-We031, 4.09.P-We067, 4.09.T-06, 4.19.P-We210, 4.19.T-04, 4.21.P-Th155

Pennington, Paul 2.10.P-We119, 5.02.T.A-02

Perala-Dewey, Jeffrey 2.13.T-02

Peram, Aadhrit 6.05.P-Th200

Pereira, Cléo 4.15.P-Tu184

Pereira, Glenda 5.09.P-Tu294

Pereira, Henrique Marcelo Gualberto 4.11.P-We162

Pereira, Joana 1.04.P-Th167

Pereira, M. Glória 2.01.T.B-03

Pereira, Patrícia 1.04.P-Th167

Perez, Edgar 1.01.T-03

Pérez, Rocío 2.02.P-Th248

Perino, Brianna 3.03.P-Tu041

Perna, John 4.17.P-Tu233

Perreault, Nancy 4.04.P-Th104

Perreault, Véronique 4.01.T-01

Perrin, Grace 3.07.P-Tu056

Perrotta, Brittany 4.17.P-Tu249, 4.22.T-06

Persaud, Daniel 4.25.T-03, 4.25.T-05

Persowich, Laurel 2.05.P-We043

Peslherbe, Gilles 1.02.T-05

Petalas, Christina 3.07.T.B-04, 3.08.P-Th042

Peters, Adam 1.01.P-Tu010, 1.01.T-04, 1.01.T-05, 2.02.P-Th276, 2.02.P-Th277

Peters, Lisa 2.09.P-Tu033, 6.03.P-Tu024

Petersen, Maggie 2.02.P-Th273

Peterson, Chris 5.05.P-We012

Peterson, Eric 5.08.P-Tu134, 5.15.P-Tu170

Peterson, Michael 4.02.P-Tu198, 4.18.P-Tu265

Petit, Alexandra 2.07.P-We056

Petrosova, Helena 5.02.P-We288

Petschick, Lara L. 7.03.P-We084

Petschick, Lara 2.01.P-Tu090

Pettem, Connor 2.02.P-Th265

Pettibone, John 4.15.T-02

Petzold, Mark 4.23.P-Tu150

Pfab, Ferdinand 1.06.P-Th027, 1.06.T-02, 1.06.T-03, 5.08.P-Tu131

Pflieger, Jean-François 3.08.T-01

Pham, Anh 6.01.T-04

Pham, Jennifer 2.01.T.B-02

Phan, Audrey 1.07.P-We088

Phan, Bich-Lien 5.10.P-We147

Phelps, Drake 1.08.P-We170

Phelps, Samantha 2.01.P-Tu080

Philibert, Aline 2.12.P-We184

Philibert, Danielle 1.03.T-04, 2.07.P-We058, 2.13.P-Th241

Philippe, Gabriel 2.14.T-05, 4.26.T-02

Phillips, Bryn 4.21.T-03, 4.23.T-04

Phillips, Jessica 2.02.P-Th251

Phillips, Logan 2.02.P-Th260, 6.03.P-Tu023

Phillips, Theresa 5.10.P-We142, 5.10.P-We143

Pickard, Heidi 4.10.P-Tu004

Pickford, Daniel 1.09.T.B-05, 1.13.P-Tu036, 1.13.T-04, 2.03.P-Th017

Pickhardt, Paul 1.06.P-Th024, 1.06.P-Th027

Picotte, Sandrine 2.01.P-Tu093

Pieddesaux, Stéphanie 2.01.P-Tu081

Pigott, Grace 4.04.P-Th105

Pike, Brian 4.02.P-Tu204

Pillai, Sashank 4.17.P-Tu238

Pilling, Ed 5.15.P-Tu167

Pina Hodges, Samuel 2.06.T-04

Pina-Leblanc, Celeste 1.02.P-We241

Pinelli, Eric 8.02.T-03

Pinsonnault Cooper, Joëlle 1.09.P-Tu121

Pirrung, Michael 2.01.P-Tu071

Pisarski, Emily 3.06.P-Tu103, 4.07.P-Tu144, 5.02.T.A-02, 6.01.T-05, 6.02.P-Th110, 7.02.T-03

Pitre, Frederic 3.06.T-04, 5.02.P-We278, 6.03.P-Tu025

Pitula, Joseph 2.07.T-04, 5.02.P-We287

Plante, Isabelle 7.04.T-01

Plotzke, Kathleen 4.04.T.A-03

Pochardt, Meredith 2.09.T-03

Pochini, Kate 4.23.P-Tu150

Pocock, Mike 3.07.P-Tu057

Podpora, Nadia 5.09.P-Tu289, 5.09.P-Tu293

Point, Adam 1.02.T-01

Poirier, Laurence 2.07.P-We056, 2.07.T-02

Poirier, Sylvie 4.18.P-Tu283

Poisson, Katherine 4.17.P-Tu244

Poliserpi, M. Belén 3.01.P-Th029

Polivka, Peter 4.02.P-Tu208

Pollesch, Nathan 4.03.T-06, 5.08.P-Tu130

Polst, Bastian 3.06.T-06

Pomerantz, William 4.09.T-04, 4.22.P-Th227

Ponce De Leon Garcia, Jose 3.08.P-Th050

Ponsin, Violaine 4.23.P-Tu157

Ponton, Dominic 2.14.P-We197, 2.14.T-01, 4.26.T-05

Pope-Buss, Riley 5.02.P-We274

Poret, Agnès 2.01.P-Tu068

Portero, Erika 4.21.P-Th153

Potts, Ryan 5.09.P-Tu291

Potvin, Catherine 3.04.P-We308

Poudel, Biplab 6.01.T-03

Poulsen, Rikke 5.02.P-We288

Poursina, Davood 5.16.P-We292

Pouyande, Sara 2.07.P-We053, 2.10.P-We116

Powell, Brian 4.13.P-Th126, 4.13.T-05

Powell, Paige 2.01.P-Tu092, 2.03.P-Th008

Powley, Charles 4.07.T-02, 4.22.P-Th214, 7.02.T-01

PP, Hitha 4.17.P-Tu238

Prajapati, Anjali 6.05.T-04

Prather, Rebecca 5.08.P-Tu130

Prayugo, Vincent 1.08.P-We169

Preisendanz, Heather E. 4.06.P-Tu215

Preuss, Thomas 5.08.P-Tu129, 5.08.P-Tu132

Prezgot, Daniel 4.15.P-Tu190

Price, Gwilym 3.03.P-Tu042

Priest, Colleen 3.02.T-04

Prieto-Espinoza, Maria 4.23.P-Tu157

Princz, Juliska I. 1.14.T-03

Princz, Juliska 1.14.P-Tu227, 1.14.T-04

Proctor, Deborah 4.18.P-Tu276

Prokopenko, Christina 4.04.P-Th105

Prosser, Ryan 1.12.P-Tu224, 2.01.P-Tu069, 2.02.P-Th263, 2.02.T-04, 2.03.P-Th010, 2.05.P-We040, 2.07.P-We058, 2.10.P-We102, 3.02.P-We034, 3.06.T-01, 4.22.T-06, 5.02.P-We279

Proulx, Catherine 1.01.T-03, 4.13.P-Th123

Provasnik, Alexandra 4.18.P-Tu275

Provencher, Jennifer 2.07.P-We055, 3.02.T-05, 3.07.T.A-02, 3.07.T.B-03, 3.08.P-Th042, 4.04.P-Th095, 4.04.P-Th096, 4.04.P-Th097

Provost-Savard, Arianne 8.09.T-01

Pu, Shirley 8.05.P-We217

Pugh, Andrea 4.18.P-Tu273

Pugh, Rebecca 4.18.P-Tu278

Puglis, Holly 4.17.P-Tu249

Pulgarin-Zapata, Daniela 4.27.P-We301

Pulster, Erin 1.06.T-01, 3.06.P-Tu105, 4.23.T-05

Punch, Rhiannon 8.02.T-05

Purucker, Tom 1.03.P-Th018, 1.04.P-Th175, 3.07.T.B-05

Putnala, Sravan Kumar 1.04.P-Th171

Pyche, Courtney 2.05.P-We042

Pyper, Brian 5.16.T-02

Q

Qanbarzadeh, Mojtaba 4.09.T-01

Qian, Xing 4.01.P-Th156, 4.21.P-Th155

Qin, Xiaohuan 4.22.P-Th214

Quackenbush, Alyssa 3.07.P-Tu050

Quaresma, Amanda de Vasconcelos 4.11.P-We162

Quiros, Amanda 2.01.P-Tu081

R

Rachels, Kyle 5.02.T.A-04

Racine, Kim 1.01.T-03

Raczkowski, Alyssya 2.02.P-Th248

Radford, Brynne 4.04.P-Th094

Ragoussis, Ioannis 8.02.T-06

Rahlfes, Lea 1.06.P-Th027

Rahman, Luna 1.07.P-We091

Rahman, Naziza 8.02.T-06

Raine, Jason 2.06.T-05, 6.01.P-We082

Raio, Joao Pedro 1.04.P-Th167

Raisebe, Florence 4.11.P-We164

Rajan, Felicia 2.02.T-02

Rakowska, Magdalena 2.06.T-04

Raldua, Demetrio 1.04.P-Th167

Ramacciotti, Francis C. 5.09.P-Tu289

Ramacciotti, Francis 5.09.P-Tu293, 5.10.P-We144, 7.02.T-02

Ramanarayanan, Tharacad 5.10.P-We145

Ramesh, Aramandla 4.22.P-Th224

Ramirez, Zealan 1.07.P-We086

Ramírez-Romero, Patricia 2.02.P-Th280, 3.06.P-Tu115, 4.15.P-Tu180

Rana, Juwel 5.10.P-We128

Rand, Amy 2.10.P-We108, 4.18.P-Tu271, 4.21.P-Th151, 6.05.T-02

Raths, Johannes 2.01.P-Tu088, 2.01.T.A-02, 4.23.P-Tu148

Ratliff, Michael 4.13.P-Th128

Rattner, Barnett 3.04.P-We305, 3.08.P-Th038

Ratzlaff, Deborah 1.09.P-Tu121

Raverty, Stephen 3.08.P-Th039

Ray, Jessica 2.13.P-Th245

Rayner, Rachael E. 1.08.P-We172

Razavi, Roxanne 4.26.T-05, 5.02.P-We286

Reardon, Catherine 4.06.P-Tu215

Rebek, Jody-Lynn 7.07.T-01

Reclus, Anna 3.07.T.B-06

Redman, Aaron 2.06.T-04, 5.01.P-We059

Reed, Melissa 5.08.P-Tu129

Reents, Hannah 2.10.P-We101, 7.02.P-Th207

Rehage, Jennifer 4.19.P-We209

Reible, Danny 4.22.T-05

Reichert, Brian 2.04.T-05

Reid, Kim 4.02.P-Tu198

Reid, Marie-Pier 4.18.P-Tu264

Reid, Mason 3.04.P-We306, 6.03.P-Tu022

Reid-Smith, Richard 8.02.T-06

Reinke, Emily 1.09.T.B-04

Reis, Paula C. J. 2.06.P-Th116

Reisch, Baylie 3.08.P-Th040

Rekully, Cameron 5.08.P-Tu130

Renard, Olivia 3.06.T-05

Renauer, Lola 3.07.P-Tu050

Renegar, D. Abigail 2.03.T-06

Renegar, Dorothy-Ellen 2.03.P-Th002

Rericha, Yvonne 5.09.P-Tu289

Reside, Amanda 3.02.P-We034

Resonno Jr., Santonio 2.01.P-Tu076

Restrepo, Catalina 4.18.P-Tu265

Restrepo, Rodrigo 4.09.P-We068

Restrepo Galvis, Catalina 4.02.P-Tu198

Reveillon, Damien 1.07.P-We097

Revel, Marion 1.02.T-06, 1.09.P-Tu124, 7.03.T-06, 7.08.P-Tu135

Reyes, Alberto 2.06.T-01

Reyes, Mikyanny 4.21.P-Th151

Reynolds Reid, Kim 4.18.P-Tu265

Reynoso-Martínez, Aquetzali 4.18.P-Tu269

Rezai, Pouya 4.15.P-Tu185

Ribeiro Rdrigues, Lucia Helena 2.03.P-Th011

RIBOUT, Cécile 3.08.P-Th044

Rich, Stephanie 4.09.T-01

Richard, Laurianne 3.07.T.A-04, 3.07.T.B-04

Richards, Agnes 4.17.T-03

Richardson, Alexandra 4.05.T-01

Richesin, Hailee 2.10.P-We121

RICKE, DYLAN 5.02.P-We283

Rico, Cyren 5.02.P-We274

Rider, Mary 7.10.P-Tu300

Riese, Katie 3.07.P-Tu056

Rifa, Rafia Afroze 1.02.P-We245

Rigsby, Jeremy 2.02.T-06

Rigutto, Gabrielle 8.08.T-04

Riis Baalkilde, Jens 5.16.T-04

Rikardsen, Audun 3.08.T-03

Riling, Don 4.23.P-Tu150

Rind, Mazhar Ali 5.09.P-Tu286

Risacher, Florent 4.05.P-Th129

Rish, William 5.09.T-01

Ritchot, Kristin 2.05.P-We043

Ritschar, Sven 5.11.P-Tu165

Ritu, Jinnath Rehana 1.15.T-04, 2.10.P-We110

Ritz, Christian 5.16.T-01

Rivas, Pierina 2.01.T.A-03

Rivera, Tamara 4.04.P-Th092, 4.04.T.A-06

Rivest, Chloé 2.14.P-We189

Rivetti, Claudia 1.05.P-Th180, 1.05.T-05

Riyahi Bakhtiari, Alireza 2.07.P-We053

Rizvi, Rayaan Kazim 1.02.T-05

Roark, Kathleen 2.01.P-Tu071, 4.22.P-Th217, 5.17.P-We258

Roark, Shaun 2.02.T-06, 5.02.T.B-06

Roberge, Marc-Olivier 2.14.P-We193

Roberge, Steeve 4.15.P-Tu184

Roberts, Andrew 4.02.P-Tu197, 4.08.P-We030

Roberts, Catherine 2.02.P-Th258, 2.13.T-05, 4.17.P-Tu250

Roberts, Simon 4.25.T-01

Robertson, Krista 2.09.P-Tu033, 6.03.P-Tu024

Robichaud, Karyn 1.02.P-We246

Robinson, Raven 3.06.P-Tu112

Robinson, Stacey 1.02.P-We246, 1.15.T-05, 2.03.P-Th007, 2.10.P-We117, 4.18.P-Tu283

Robitaille, Julie 1.05.P-Th185, 1.05.T-06, 5.17.P-We259

Robrock, Kristin 4.02.T-02

Roche, Dominique 3.07.V-01

Rochepeau, Adam 4.02.P-Tu195

Rochman, Chelsea M. 3.08.P-Th050

Rochman, Chelsea 2.03.P-Th010, 3.02.T-05, 4.24.T-03

Rock, Kylie 2.01.P-Tu092, 2.03.P-Th008, 3.08.P-Th052

Rodea-Palomares, Ismael 5.18.P-We023

Rodgers, Tim 4.17.T-05, 7.05.P-We158

Rodgers, Timothy F. M. 4.17.T-03

Rødland, Elisabeth 4.17.T-01, 4.24.P-We227

Rodrigues, Cândido 2.14.T-04

Rodriguez, Denice 4.04.T.B-01

Rodriguez, Jair 5.09.P-Tu294

Rodriguez Fuentes, Gabriela 2.02.P-Th259, 4.18.P-Tu269, 5.09.P-Tu298, 7.05.P-We157

Rodriguez Gil, Jose Luis 2.02.P-Th252, 2.08.P-Tu059, 2.08.P-Tu060, 2.08.P-Tu061, 4.09.P-We070, 5.04.P-We251, 5.04.P-We253, 5.04.T-04, 5.04.T-06

Rodriguez Ramirez, Mayre 4.25.T-05, 4.25.T-06

Rodriguez-Gil, Jose Luis 2.01.P-Tu071

Rodríguez-Maese, Rogelio 4.07.V-01

Rodriguez-Rodriguez, Carlos E. 5.14.P-Th198

Rodriguez-Saldana, Veronica 4.07.V-01

Roesner, Joern 3.06.T-06

Roessink, Ivo 2.01.T.A-04

Roffler, Gretchen 4.04.P-Th105

Rogalski, Maya 4.06.P-Tu210

Rogers, Holly 3.07.T.B-05, 5.08.P-Tu130

Rohlman, Diana 4.05.P-Th146, 4.10.T-03

Rojnik, Mayda 5.10.P-We153

Rojo, Macarena 4.06.P-Tu218

Romanak, Kevin 4.06.T-06

Romaniuk., Nikolas 6.03.P-Tu030

Romanok, Kristin 4.08.P-We029

Romero, Juan 5.09.P-Tu294

Romero Alfano, Irene 1.04.P-Th167

Rondeau, Marie-Helene 2.01.P-Tu081

Rondinelli, Mia 4.24.P-We224

Rondon Werneck, Max 3.07.T.A-05

Ronur Praful, Tejaswini 4.27.T-02

Roosenburg, Willem 3.02.T-06

Ropers, Marie-Hélène 2.07.T-02

Rosa, Philippe 2.07.P-We056

Rosabal, Maikel 1.01.T-03, 1.07.P-We085, 2.14.P-We188, 2.14.P-We191, 2.14.P-We192, 2.14.P-We193, 2.14.P-We194, 2.14.P-We196, 2.14.T-01, 2.14.T-04, 2.14.T-06, 3.03.P-Tu041, 3.08.T-01, 4.04.T.A-01, 4.13.P-Th124, 4.14.P-We176, 4.18.P-Tu280

Rosario, Victoria 6.05.T-03

Rosario-Ortiz, Fernando 4.10.T-04

Rosebrugh, Mackenzie 4.27.T-06

Rosen, Gunter 4.05.P-Th129

Rosen, Gunther 5.02.T.B-02

Rosnack, Kenneth 4.02.P-Tu201

Rosniak, Ryan 2.07.P-We058

Ross, Andrew R. S. 4.17.T-03

Ross, Matthew 4.04.P-Th093, 4.04.P-Th094

Ross, Peter 5.07.T-05

Ross, Peter S. 2.07.P-We050, 2.13.P-Th238

Rossen, Ariana 4.11.P-We161

Rostami, Fariba 4.22.P-Th236

Rostan, Vanesa 4.23.P-Tu161

Roth-Monzón, Andrea 1.08.P-We167

Rotondo, Davide 5.02.T.A-05

Roush, Kyle 1.09.T.B-02

Routhier, Evan 4.10.T-02

Rowan, Evelyn 4.05.P-Th138

Rowe, Christopher 3.02.T-06

Rowell, Abigail 4.13.P-Th126

Roy, Ranjan 4.15.T-01

Roy-Lachapelle, Audrey 4.01.P-Th162

Roylance, Kate 1.13.P-Tu039

Rudisill, Catherine 8.08.P-Tu308

Rudy, Martina 2.06.P-Th120

Ruecker, Norma 4.27.T-06

Ruiz, Jorge 1.09.P-Tu118

Rumbeiha, Wilson 1.07.P-We086, 4.22.P-Th224, 7.05.P-We156

Rupprecht, Gabrielle 3.07.P-Tu054

Ruszala, Paul 5.09.P-Tu288

Rutkiewicz, Jennifer 8.08.T-05

Ryan, Adam 1.01.T-02

Ryan, Kristen 1.09.T.B-04

Ryu, Seohee 1.07.P-We086

S

Saadi, Nadim 8.01.T-01

Saari, Brooke 7.11.P-Tu303

Sachs, Gage 3.07.T.B-05

Saddler, Trey 7.08.P-Tu136

Sadiq, Aqsa 1.10.T-05

Sagua, Mara I. 4.11.P-We161

Saherwala, Arav 4.15.P-Tu172, 4.15.P-Tu173, 4.15.T-06

Sahlin, Ullrika 5.16.P-We297

Sai Samhitha, Vajja 2.01.P-Tu089

Saidani, Michael 8.04.P-Tu016

Saini, Amandeep 3.01.T-01

Saint-Louis, Richard 2.01.P-Tu081, 2.03.P-Th003, 2.03.P-Th004, 2.10.P-We115

Sakamoto, Masaki 4.17.P-Tu234

Sakib, Sadman 4.15.P-Tu190

Saleem, Muhammad 5.10.P-We126

Salgado, Cástor 8.03.T-02

Salice, Christopher 4.06.P-Tu216

Salinas, Edward 1.13.T-05, 5.08.P-Tu132

Salinas-Rodriguez, Zoe 4.17.T-05

Saliu, Toyin Dunsin 4.22.T-04

Saliu, Toyin 5.02.T.B-05

SALLEM, Fadoua 3.06.P-Tu110

Salles, Paulo 7.05.P-We157

Salole, Jack 1.07.P-We094, 1.09.P-Tu116, 2.03.T-04

Salvador, Christian 1.06.P-Th024

Salvitti, Michella 2.07.T-04, 3.03.P-Tu044, 4.23.P-Tu156

Samel, Alan 2.03.T-01, 2.03.T-02, 5.15.P-Tu169

Sample, Bradley 3.04.P-We307

Sanborn, Michael 2.14.P-We197

Sanchez Garcia, Andres 4.22.T-05

Sander, Louis-Marvin 5.14.T-01

Sanders, Corey 2.13.P-Th243

Sanders, Todd 3.08.P-Th038

Sandre, Fidji 2.09.T-02, 2.09.T-06

Sandro, Jonalyn 5.09.P-Tu294

Sandy, Andy 5.17.P-We260

Sangion, Alessandro 1.09.P-Tu122, 1.09.P-Tu127, 4.03.T-03, 4.09.P-We072, 4.22.P-Th230, 5.01.P-We059, 5.01.P-We060, 5.01.T-04

Sangiovanni, Jonathan 1.03.T-04, 3.01.T-04, 3.08.P-Th036

Sangwan, Anju 8.03.P-We004

Sankey, Justin 4.09.P-We069

Sankula, Sujatha 3.07.T.B-05

Sanson, Ananda Lima 4.11.P-We162

SantaLucia, Kara 3.02.P-We032

Santamaria Cervantes, Claudia 3.01.P-Th029

Santander, Javier 1.04.P-Th173, 2.03.P-Th005

Santillan, Donna 5.02.P-We285

Santillan, Mark 5.02.P-We285

Santore, Robert 1.01.T-02

Santoyo-Tepole, Fortunata 2.01.P-Tu095

Sapanara, Maryann 5.09.P-Tu295

Sappington, Keith 3.07.T.B-05, 5.08.P-Tu130

Sarmikasoglou, Efstathios 8.03.P-We010

Sarracco, Nicolas 4.05.P-Th139

Sasidharan, Sankar 2.07.P-We057

Sauer, Ursula 1.13.T-05

Sauermilch, Isabel 4.04.T.A-03

Saunders, Leslie 1.13.P-Tu039

Sauvé, Marie-Claude 1.09.P-Tu121, 4.18.P-Tu283

Sauve, Sebastien 3.08.T-01, 4.15.T-04, 5.02.P-We278, 5.16.T-06, 6.03.P-Tu025

Sauvé, Sébastien 4.15.P-Tu184, 4.22.T-04, 5.02.T.B-05

Savage, Georgie 2.07.T-05, 4.05.T-01

Savallampi, Jasmine 8.01.T-03

Schäfer, Matthis 7.07.T-02, 7.10.P-Tu301

Schaller, Stephan 4.03.T-01

Schebel, Alixandra 2.01.P-Tu069

Scheld, Andrew 4.15.T-03

Scheringer, Martin 4.04.P-Th086

Scheurer, Marco 4.09.T-05

Schew, William 5.09.P-Tu288, 6.01.P-We081, 7.02.T-02

Schiaffino, M. Romina 4.11.P-We161

Schiff, Ken 2.05.T-06

Schirmel, Jens 2.01.P-Tu089

Schirmer, Kristin 1.02.T-06, 1.09.P-Tu124, 7.03.T-06, 7.08.P-Tu135

Schisler, George 2.10.P-We107

Schmidt, Jacob 4.22.P-Th232

Schmidt, Travis S. 1.15.P-We200

Schmidt, Travis 1.15.T-03, 2.14.T-03

Schmitt, Uwe 1.09.P-Tu124

Schneider, Danilo 2.13.T-06

Schneider, Suzanne 2.03.T-01, 2.03.T-02, 5.01.P-We066

Schock, Danna 2.06.P-Th118

Schoenung, Julie 8.08.P-Tu306, 8.08.P-Tu307, 8.08.T-03

Scholes, Rachel 2.07.P-We048, 4.17.T-03, 4.17.T-05

Scholz, Nathaniel 4.17.P-Tu246

Schopfer, Christel 1.13.T-05

Schott, Evangeline 1.08.P-We172

Schreiber, Benjamin 5.08.P-Tu129

Schreiner, Molly 4.08.P-We029

Schroeder, Carolyn 5.08.P-Tu130

Schroeder, Suzannah 2.05.P-We043

Schubert, Stefan 4.23.P-Tu158

Schulte, Patricia 2.08.P-Tu062

Schultz, Aaron 3.08.P-Th037

Schultz, Irvin 4.04.P-Th099, 4.17.P-Tu246

Schultz, Matthew 2.01.T.B-01, 5.01.T-03

Schultz, Sandra 3.01.P-Th031

Schultz, Tom F. 3.07.P-Tu054

Schulz, Ralf 2.01.P-Tu089, 2.01.P-Tu090, 4.23.P-Tu149

Schür, Christoph 1.09.P-Tu124, 7.03.T-06

Schutten, Kerry 3.07.T.B-03

Schwartz, Geoffrey 5.09.P-Tu295

Schwarzbauer, Jan 4.10.T-06, 4.26.T-03

Schwenk, Klaus 2.01.P-Tu089

Schwertfeger, Dina 1.14.P-Tu227

Scinto, Leonard 4.27.P-We300

Scorza Junior, Romulo 5.11.P-Tu163

Scott, Geoff 3.07.P-Tu050

Scroggins, Rick 1.14.P-Tu227

Seabrook, Katryna 4.17.P-Tu250

Seals, Brady 8.09.T-04

Sedlak, David 5.02.P-We270

Seeley, Meredith 4.15.P-Tu174, 4.15.P-Tu175, 4.15.P-Tu176, 4.15.P-Tu178, 4.15.T-03, 4.24.T-03, 4.27.T-02

Seethram, Maya 2.08.P-Tu063

Segarra, Amelie 7.10.P-Tu299

Segner, Helmut 1.07.P-We088

Séguin, Charles 4.23.P-Tu152

Seguin, Philippe 4.23.P-Tu152

Ségur, Théo 3.06.T-05

Segura, Pedro A. 4.01.T-03

Seidel, Pauline 2.13.T-06

Selch, Trevor 1.15.T-03

Selden, Sara 3.04.P-We309

Selinger, Sabrina 2.13.T-06

Seltmann, Jens 4.02.P-Tu204

Senanayake, Nipuna 4.19.P-We211

Sens, Donald A. 5.10.P-We126

Seo, Yonghwee 8.06.P-Th186

Seoh, Na-Yung 4.25.T-05

Sequeira, Samuel A. 3.02.P-We035

Sequeira, Samuel 2.02.P-Th260, 2.02.P-Th268, 6.03.P-Tu023

Sergues, Edgar 8.01.T-04

Servos, Mark 2.01.P-Tu085, 2.02.P-Th261, 2.10.P-We099, 4.22.P-Th215, 4.22.P-Th216, 5.17.P-We262, 5.17.P-We263

Seston, Rita 4.04.T.A-03

Seth Carley, Danesha 5.05.P-We012

Sett, Amy 4.16.T-04, 5.02.T.B-01

Severino, Suzie 2.03.P-Th004, 2.05.T-05

Sexton, Alexandra 1.06.P-Th024, 1.06.T-02, 1.06.T-03, 5.08.P-Tu131

SGABIERO, Gabriel 3.06.P-Tu110

Shaddrix, Brian 4.07.P-Tu144

Shadid, Sakina 4.05.P-Th144

Shah, Keval 6.01.T-04

Shaikh, Basheer 4.02.P-Tu194

Shalin, Anna 7.07.T-02, 7.10.P-Tu301

Shallcross, Dudley 4.25.T-04

Shams, Roomana 5.02.P-We282

Shankar, Prarthana 1.08.P-We166, 4.09.P-We076

Shanmuganathan, Meera 4.21.P-Th150

Shantau, Jennifer 1.15.P-We202

Shao, Kan 5.16.T-05

Shapiro, Jesse 8.02.T-04

Sharin, Tasnia 1.02.P-We240, 1.09.T.B-01

Sharma, Aashiya 2.08.P-Tu060

Sharma, Gopal 4.17.T-05

Sharpe, Emma 1.09.T.A-04, 5.16.P-We296

Sharron, Steve 2.09.T-03

Shata, Sahar 8.08.P-Tu306, 8.08.P-Tu307

She, Zhe 4.07.T-06

Shea, Damian 4.05.P-Th136, 4.26.P-Th284

Shea, Norm 2.01.P-Tu092

Shelton, Tara 4.22.P-Th234, 4.23.P-Tu147

Shen, Haitao 5.01.P-We065

Shen, Hongru 4.09.P-We067

Shepard, Isaac 2.10.P-We100
Sherer, Eric 1.02.T-04
Shields, Michael 4.04.P-Th099
Shiels, Aaron 3.08.T-04
Shimasaki, Yohei 2.10.P-We118
Shimizu, Megumi 4.19.T-03
Shin, Hyejin 1.10.P-We302
Shin, Mangong 4.01.P-Th161
Shires, Kallie 2.10.P-We117, 2.14.P-We190
Shirey, Melissa 2.09.T-04
Shobowale, Karimot 4.02.P-Tu207
Shotyk, William 4.14.P-We178
Shoulds, Ayanna 4.23.P-Tu158
Shrestha, Om 4.07.P-Tu139, 5.17.P-We260
Shunthirasingham, Chuba 4.25.T-03
Shunthirasingham, Chubashini 4.05.P-Th134
Shurgold, Jayson 8.02.T-02
Sibat, Manoella 1.07.P-We097
Siboo, Ian 6.01.T-04
Siccardi, Marco 4.03.T-01
Sickler, Lee 2.01.P-Tu089
Sidhu, Harmanpreet S 5.09.T-03
Sidhu, Lauren 1.05.P-Th178
Siebert, Hannah 2.01.P-Tu089
Siebke loge, Oda 4.04.T.A-03
Sieg, Chloe 5.15.P-Tu170
Sigler, W. Adam 4.08.P-We029
Sigman, Emily 4.06.T-03
Sigman-Lowery, Anthony 5.01.T-06
Sigouin, Evelyne 2.01.P-Tu081

Silvestre, Frédéric 3.03.P-Tu041

Sim, Eon-Seok 6.03.P-Tu020

Simard, Marie-Christine 4.14.P-We177

Simard, Sabrina 4.01.T-01, 4.02.P-Tu193

Simek, Zdenek 4.16.V-01

Simmons, Denina 1.02.T-01, 1.09.P-Tu128, 2.10.P-We106, 4.03.P-Th165, 4.12.P-Tu258, 4.13.P-Th125, 5.02.P-We282, 5.04.P-We251, 5.04.T-06, 5.17.P-We264, 5.17.P-We265, 5.17.P-We266, 5.17.P-We267

Simone, Ryan 2.10.P-We098

Simpson, Kayla 4.22.T-02

Sims, Jaylen 1.13.P-Tu034, 1.13.T-01

Simsek, Irem 1.14.T-03, 1.14.T-04

Sinche Chele, Federico 1.06.P-Th024

Sindiku, Omotayo 5.01.T-01

Singbeil, Brooke 4.09.P-We070

Singh, Neetu 8.03.P-We004

Singh, Paridhi 1.14.T-01

Singh, Pavitar 5.03.P-We212

Sinkway, Thomas 4.02.T-03, 4.06.T-04

Sinnathamby, Sumathy 5.08.P-Tu130

Sipos, Michael 5.02.P-We275

Situ, Fiona 1.02.P-We241

Skelton, Ellen Regina 2.03.T-06

Skigen-Caird, Sarah 1.15.P-We202

Skrivseth, Kasey 3.03.P-Tu043

Slabaugh, Caitlin 1.08.P-We166

Slater, Greg 5.09.T-03

Slaughter, Celia 4.15.P-Tu188

Sleno, Lekha 2.14.P-We188

Sluka, Henry 4.02.P-Tu202

Smalling, Kelly 3.02.T-01, 3.02.T-03, 4.08.P-We029, 4.17.P-Tu241, 4.17.T-04

Smik, Lukas 4.22.P-Th225

Smith, Abraham 2.06.T-04

Smith, Daryl 1.09.P-Tu121

Smith, Elizabeth 4.19.T-02

Smith, Erin 1.01.P-Tu010

Smith, Jayme 2.05.T-06

Smith, Latasha 5.08.P-Tu130

Smith, Matthew 4.19.P-We208

Smith, Philip 5.15.P-Tu170

Smith, Rhiannon 1.10.T-01, 1.13.P-Tu039, 2.02.P-Th256, 2.06.P-Th121

Smith, Scott 3.02.T-06

Smith, Sierra 4.05.P-Th144

Smol, John 2.01.T.B-02

Smyth, Anne 4.22.T-04

Smyth, Shirley Anne 2.05.T-04, 4.18.P-Tu266, 4.22.P-Th231

Smythe, Tristan 3.01.T-01, 3.01.T-02, 3.01.T-05, 3.08.P-Th045, 4.18.P-Tu283

Sneckenberger, Glenn 5.01.P-We064

Snoj, Luka 4.23.T-02

Snyder, Susan 6.01.T-05, 6.02.P-Th110

Soares Quinete, Natalia 3.06.V-01, 4.06.P-Tu218

Sobolewski, Tess 4.08.P-We029

Soccorsy, Nathan 2.05.P-We043

Sokalchuk Sokalchuk, Liliya 1.04.P-Th166, 1.13.P-Tu038

Solan, Megan 1.10.T-04

Solé, Magali 3.06.T-06

Solliec, Morgan 4.01.P-Th162, 4.17.P-Tu240

Solomon, Keith 5.02.T.B-03, 5.10.P-We145

Somarelli, Jason A. 3.07.P-Tu054

Somji, Seema 5.10.P-We126

Søndergaard, Jens 3.08.T-03

Song, Lauren 4.03.P-Th165

Song, Ye-won 4.05.P-Th143

Soni, Manish 8.09.T-04

Sonia, Brugel 4.04.P-Th087

Sonne, Christian 3.08.T-03

Sontarp, Ethan 4.10.T-02

Sopko, Xiaoyi 5.16.P-We292

Sorensen, Kaede 3.08.P-Th050

Sorum, Mathew 4.04.P-Th105

Soto, Javier 4.24.P-We230

Soto-García, Erick 7.05.P-We157

Soubaneh, Youssouf Djibril 4.24.P-We228

Soucek, David 1.06.T-01, 4.17.P-Tu247, 4.17.P-Tu249

Soulsbury, Kevin 2.13.P-Th238, 4.17.T-03

Sousa, Ana Isabel 2.07.P-We056

Sousa, Jose Paulo 5.15.P-Tu166

Southern, India 2.05.T-03

Souza, Tais 4.22.P-Th227

Sow, Aissatou Y 4.19.T-01

Sowa, Grzegorz 5.15.P-Tu166

Spaak, Jürg 2.01.P-Tu089

Spegar (Anderson), Kursten 5.05.P-We017

Spilinek, Sterling 4.04.P-Th105

Spooner, Ian 2.07.P-We055, 4.26.P-Th283

Spooner, Megan 2.09.T-04

Spooner, Zeke 3.08.P-Th049

Spromberg, Julann 4.17.P-Tu246

Spurgeon, David 2.01.T.B-03

St-Hilaire, Sabrina 2.04.P-Tu102, 2.04.T-06

St-Louis, Richard 2.05.T-05, 2.14.T-06, 4.04.T.A-01

St-Martin, Maxime 6.01.T-01

St. Clair, Ashley 5.18.P-We019

Staffens, Kristen 4.15.T-02

Stanbro, Kelsey 4.04.P-Th105

Stanhope, David 4.15.T-03

Staniec, Kelsey 4.25.P-Th194

Stanley, Madeline 2.09.P-Tu033, 6.03.P-Tu024

Stapleton, Heather 4.06.T-05

Stark, John 3.08.T-04, 5.16.T-03

Staub, Leah 4.17.P-Tu241

Staub, Ryan 1.03.P-Th020, 1.05.P-Th181, 1.05.T-03

Stavros, HuiChen 4.02.P-Tu204

Stebbins, Katherine 5.08.P-Tu130

Stebel, Eva 8.05.P-We217

Steele, Joshua 2.05.T-06

Steer, Scott 3.07.P-Tu053

Steevens, Jeff 2.02.P-Th274, 6.01.T-03

Stein, Daniel 2.01.P-Tu069

Stein, Lina 2.01.P-Tu089

Stemmler, Elizabeth 4.09.P-We073, 4.09.P-We075

Stenner, Katelyn 1.15.P-We203

Stern, Gary 4.04.P-Th093, 4.04.T.A-04

Stern, Jule Sophie 2.01.P-Tu089

Steven, Blaire 8.03.P-We003

Stevens, Doug 4.07.P-Tu145

Stevens, Peter 2.01.P-Tu072

Stevenson, Louise 1.06.P-Th024, 1.06.P-Th027, 1.06.T-02, 1.06.T-03, 5.08.P-Tu131

Stevenson, Ryan 2.02.P-Th269

Stewart, Emma 3.07.P-Tu054

Stewart, Hannah 5.05.P-We014, 5.05.P-We016

Stewart, Justin 1.05.P-Th182, 1.05.T-02, 1.06.P-Th026, 1.06.T-05

Stiborek, Marek 4.16.V-01

Stimmelmayr, Raphaela 4.04.P-Th099

Stobbs, Jarvis 1.08.P-We168

Stoddart, Gilly 1.09.P-Tu124, 7.03.T-06

Stohl, Andreas 4.24.P-We226

Storck, Veronika 8.02.P-We257

Strang, Benjamin 4.04.P-Th090, 4.04.T.B-01

Strauch, Cassandra 3.07.T.B-05

Strauss, Tido 5.08.P-Tu133

Straw, Bethany 2.04.T-05

Street, Elle 4.13.P-Th128

Streeter, Shyla 1.08.P-We170

Strosnider, William H.J. 2.13.P-Th246

Strosnider, William HJ 7.11.P-Tu303

Stuart, Marilyne 1.01.T-03, 1.05.P-Th178, 4.13.T-03

Stubblefield, William 5.10.P-We134

Stunz, Gregory 2.12.P-We187

Stup, Kevin 4.02.P-Tu201

Sturgeon, Cody 5.03.P-We212

Stutts, Lauren 5.05.P-We012

Su, Celine 4.01.P-Th157

Su, Geoffrey 2.09.T-04

Su, Yushan 4.01.T-04, 4.19.P-We210

Subedi, Sanjeena 1.09.P-Tu125

Šubelj, Gašper 2.01.P-Tu078, 4.23.T-02

Suchana, Shamsunnahar 4.15.T-06, 4.22.P-Th233

Suehring, Roxana 4.05.P-Th131, 4.24.P-We218, 4.24.T-02

Sugawara, Kazuki 4.24.P-We232

Sugiura, Tomoko 5.04.P-We247

Sulaimon, Ridwan 1.02.T-05

Sulbæk Anderson, Mads 5.02.T.B-03

Sullivan, Emma 4.04.P-Th090, 4.04.T.B-01

Sullivan, Katrina 4.17.P-Tu232, 4.17.P-Tu237, 5.10.P-We148

Sullivan, Mark 2.07.P-We047

Sultan, Amany 5.02.P-We282

Sumikawa, Towa 4.24.P-We232

Sun, Jennifer 3.07.P-Tu045, 4.10.P-Tu004

Sun, Jianxian 4.21.P-Th155

Sunderland, Elsie 4.10.P-Tu004, 4.10.T-02

Sunyer-Caldú, Adrià 4.05.P-Th134

Surette, Mark 4.02.P-Tu208

Suripto, Aisyah 2.03.P-Th001, 3.08.P-Th051

Sutedja, Jocelyn 2.07.T-02

Sutton, Rebecca 2.13.T-04, 3.07.P-Tu045, 4.21.P-Th147, 4.21.T-06, 4.24.P-We227, 5.04.T-03, 5.04.T-05

Suzuki, Go 4.24.P-We236

Suzuki, Risa 4.07.P-Tu139

Suzuki, Takahiro 1.09.T.B-02, 2.07.P-We052, 5.09.T-02

Svendsen, Claus 3.07.T.A-06

Swam-Jaramillo, Lauren 7.10.P-Tu300

Swearingen, Cadance 3.02.P-We038

Sweeney, Corinne 2.02.P-Th274

Switzer, Alexandra 2.02.T-04

Syama, Krishna Priya 1.09.P-Tu125, 5.10.P-We128

Synhaeve, Nicholas 1.13.P-Tu039

Sysoeva, Laura 2.02.P-Th277

T

Tabora Sarmiento, Shisbeth 1.04.P-Th174, 2.05.P-We041, 2.05.P-We042, 2.05.T-01, 4.06.P-Tu217

Taggart, Connnor 4.01.P-Th160

Tagliati, Alice 5.08.P-Tu132

Tagmount, Mani 1.05.P-Th179

Tai, Rie 2.03.P-Th016

Tait, Noah 4.15.T-03

Takagi, Toshiyuki 2.07.P-We052

Takahashi, Yusuke 4.24.P-We236

Takai, Yuki 2.10.P-We118

Tambling, Todd 2.02.P-Th258, 2.02.T-06

Tan, Yujing 4.24.T-05

Tan Sépot, Anna 1.13.P-Tu039

Tanaka, Kosuke 4.24.P-We236

Tanguay, Xavier 8.04.P-Tu019

Tannahill, Oliver 4.09.P-We075

Tanoue, Rumi 2.10.P-We109

Tao, Tim 4.21.P-Th155

Taranu, Zofia 2.01.T.B-02

Tardif, Geneviève 4.18.P-Tu283

Tatara, Christopher 4.17.P-Tu246

Tatarazako, Norihisa 1.10.P-We304, 2.10.P-We120

Tatters, Avery 5.10.P-We152

Taulbee, Keith 2.02.P-Th273

Taylor, Jadlyn 5.02.P-We287

Taylor, Lisa 1.09.P-Tu116, 2.03.T-04, 2.07.T-01

Teaniniuraitemoana, Vaihiti 1.07.P-We097

Técher, Romy 7.04.T-01

Teed, R. Scott 5.15.P-Tu169

Teed, Scott 5.18.P-We023

Teigen, Megan 6.05.T-03

Tejerina, Luis 1.04.P-Th173

Tejerina Pardo, Luis 2.03.P-Th005

Tellez, Marisa 3.02.P-We033

Tempkin, Alexis 8.08.P-Tu308

Temple, Diana 3.04.P-We310, 3.07.P-Tu057

Ternes, Thomas 4.09.T-05

Teslic, Steven 4.22.P-Th231

Testa, Maria Giulia 1.14.T-04

Tetreault, Gerald 2.05.T-04, 4.04.P-Th091, 4.04.P-Th107, 4.04.T.A-04, 4.04.T.A-05

Thacker, Robert J 4.13.T-06

Thackray, Colin 4.10.P-Tu004, 4.10.T-02

Thakre, Piyush 4.24.T-05

Thapalia, Anita 4.05.T-05, 5.02.P-We268, 5.02.T.A-01

Thatcher, Anne 3.04.P-We309

Thellman, Paul 2.02.P-Th255

Theodorakis, Christopher 2.02.P-Th254

Thibault, Romain 3.03.P-Tu041

Thibodeau, Alexandre J. 2.09.T-05

Thibodeau, Alexandre 4.14.P-We179, 8.02.T-03

Thiffault, Évelyne 8.09.T-03

Thirugnanasambandam, Ilakkiya 4.22.P-Th234, 4.23.P-Tu147

Thom, Theresa 2.05.T-03

Thomas, Amy 1.13.P-Tu034

Thomas, James 4.21.T-01

Thomas, Jith 1.09.P-Tu125

Thomas, Kevin 3.03.P-Tu042

Thomas, Philippe J. 2.06.T-02

Thomas, Phillipe 2.06.P-Th114, 2.06.T-03

Thomas, Robert 2.05.P-We043

Thomas, Tiffany 4.02.T-02

Thomassin, Paul 8.02.T-06

Thomisee, Taylor 6.03.P-Tu029

Thompson, Andrew 2.04.P-Tu102, 2.04.T-01, 2.04.T-04, 2.04.T-06

Thompson, Darrin 5.02.P-We285

Thompson, Helen 3.07.P-Tu057, 5.15.P-Tu169

Thorbek, Pernille 5.08.P-Tu129

Thornton Hampton, Leah 4.15.T-05

Thouvenot, Emanuelle 1.13.P-Tu037

Tian, Zhenyu 4.17.P-Tu244

Tickner, Joel 8.08.T-06

Tidwell, Lane 4.05.P-Th135, 4.05.P-Th141, 4.05.P-Th142, 4.05.P-Th145, 4.05.P-Th146, 4.27.T-05

Tier 0 Database Working Group, HESI Global UVCB Committee 1.10.T-03

Tighe, Robert M. 1.08.P-We172

Tillema, Shelby J. 5.04.T-01

Tillitt, Donald 3.08.T-06

Tilzey, Allison 8.05.P-We216

Timlick, Lauren 2.01.P-Tu071, 2.02.P-Th252, 2.06.P-Th115, 5.04.P-We253, 5.04.T-04, 5.04.T-06

Tindall, Andrew 1.07.P-We088

Tjeerdema, Ronald 4.23.T-04

To, Tuan Anh 2.09.T-02

Tokranov, Andrea 3.02.T-06

Toll, John 5.02.P-We289

Tollemer, Marianne 8.09.P-Tu312

Tomy, Gregg T. 2.06.T-02, 4.12.P-Tu254

Tomy, Gregg 1.03.T-04, 4.04.P-Th095, 4.04.P-Th096, 4.04.P-Th097, 4.07.T-01

Tomy, Thane 4.07.T-01, 4.12.P-Tu254

Toose, Liisa 4.04.P-Th086, 4.22.P-Th230, 5.01.P-We060, 5.01.T-04

Torano, Olivia 1.02.T-02, 2.10.P-We112

Tornabene, Brian 3.02.T-01, 3.02.T-03

Torres, Leigh 4.24.P-We235

Torres Duarte, Cristina 2.03.P-Th001, 3.08.P-Th049, 3.08.P-Th051

Torzone, Andrea 3.02.P-We033

Tosic, Oliver 2.06.P-Th121

TP, Vinod 4.24.P-We221

Tran, Anh 2.13.P-Th242

Tran, Huy 8.09.T-04

Tran, Olivia 1.13.P-Tu039

Tremblay, Geneviève 4.24.P-We220, 4.25.P-Th191, 4.25.T-02

Tremblay, Louis 5.07.T-02, 7.07.T-03

Tremblay, Pascale 6.01.T-01

Tremblay, Réjean 2.03.P-Th003, 2.03.P-Th004, 2.05.T-05

Tremblay, Valérie 2.14.P-We197

Trémolet, Gauthier 2.01.P-Tu068

Trenfield, Melanie 1.01.T-05, 2.02.P-Th276, 2.02.P-Th277

Trevor, Kyle 4.04.T.B-01

Trivedi, Purushottam 4.02.P-Tu194

Troncy, Clementine 4.15.T-04

Troutman, Jacob 5.03.P-We214

Troxell, Kassidy 2.10.P-We098, 4.12.P-Tu256, 4.18.P-Tu263, 4.19.P-We209, 4.21.T-02

Truffer, Bernhard 7.08.P-Tu135

Tryc, Matthew 1.15.P-We203

Tsang, Camille 4.01.P-Th335

Tsotetsi, Teboho 8.03.T-04

Tsuchiya, Yuko 4.18.P-Tu268

Tsuji, Leonard 5.10.P-We129

Tsujino, Hirofumi 4.15.P-Tu189

Tsutsumi, Ryotaro 4.15.P-Tu189

Tsutsumi, Yasuo 4.15.P-Tu189

Tu, Qingshi 8.09.T-05

Tuberville, Tracey 3.02.P-We036

Tufenkji, Nathalie 1.14.T-06, 2.03.P-Th007, 4.15.P-Tu172, 4.15.P-Tu173, 4.15.T-06, 4.22.P-Th233, 4.24.P-We219, 4.24.T-06

Tunali, Merve 3.06.P-Tu108

Turcotte, Patrice 4.18.P-Tu266

Turner, Nicholas 1.03.T-03, 1.09.T.A-03, 2.02.P-Th272

Turquois, Coralie 3.07.P-Tu055, 3.07.T.B-02

Tweel, Andrew 2.01.P-Tu092

Tyler, Charles 4.21.T-01, 5.08.P-Tu129

Tysklind, Mats 4.04.T.A-02

U

Uch, Sao 3.03.P-Tu043

Uchimura, Mirai 1.05.P-Th184, 2.07.P-We054

UCHIMURA, MIRAI 3.07.P-Tu058

UDDIN, MD HELAL 1.15.T-04, 2.10.P-We110

Udoh, Enobong 2.01.T-05, 2.02.P-Th260, 2.02.P-Th268, 6.03.P-Tu023

Ueda, Koji 5.10.P-We146

Ueda, Yuusuke 2.10.P-We118, 7.04.T-05

Ugbogu, Ositadinma Chinyere 8.03.P-We001

Ukropec, Jacob 4.15.P-Tu174

Ullah, Zaib 3.08.P-Th037

Ulrich, Bridget 2.13.P-Th244, 4.17.T-02

Uno, Seiichi 1.05.P-Th184, 2.02.P-Th271, 2.07.P-We054, 3.07.P-Tu058, 4.09.P-We071, 4.17.P-Tu234, 4.17.P-Tu235, 4.24.P-We236

Uribe López, Jonathan 2.02.P-Th259

Urwin, Derek 4.19.T-06

Ushioka, Satoshi 5.01.P-We062

Ussery, Erin 1.02.P-We242, 2.01.P-Tu071, 2.03.T-04, 2.06.P-Th120, 5.02.T.B-01

Utting, Nicholas 4.18.P-Tu274

Utz, Jamie 4.23.T-05

Uusitalo, Ville 8.01.T-03

V

Vachon, Dominic 6.01.T-01

Vaezafshar, Sara 4.01.P-Th335, 4.01.T-06, 4.21.P-Th150

Vakharia, Rashne 5.17.P-We263

Valderrama Londono, Roger Ivan 2.10.P-We113

Valentine, David 4.22.P-Th232

Valentine, Holly 6.05.T-03

Valverde-Barrantes, Oscar J. 3.06.V-01

Vamshi, Raghu 5.11.P-Tu164, 5.18.P-We020

van den Brink, Paul 2.01.T.A-04

Van den Brink, Paul 2.01.T.A-03

van den Hurk, Peter 2.03.P-Th008

Van den Hurk, Peter 2.10.P-We123

Van der Linden, Inge 3.06.T-06

van der Marel, Christina 4.10.T-06, 4.26.T-03

van der Schyff, Veronica 4.16.V-01

van der Velden, Miguel 7.07.T-02

Van der Vliet, Leana 2.07.T-01

Van Leuven, Tristan 2.01.P-Tu072

Van Meter, Robin 1.04.P-Th175

van Tussenbroek, Emma 1.15.P-We203

Van Winkle, Laura 1.10.T-06, 7.05.P-We156

Vanden Heuvel, Abigail 3.07.T.A-01

VandenBoer, Trevor 4.01.T-04, 4.10.P-Tu001, 4.10.P-Tu006, 4.25.P-Th192, 4.25.T-03, 4.25.T-05, 4.25.T-06

Vander Meulen, Ian J 2.06.P-Th113

Vander Meulen, Ian 2.06.P-Th119

VanderMeulen, Emma 5.14.T-04

Vanhauwaert, Eric 4.25.T-03, 4.25.T-05

Vanrobaeys, Jason 4.23.P-Tu153, 4.23.T-06

VanWoerkom, Drew 3.07.T.A-01

VanWoerKom, Drew 3.08.T-06

Vareman, Niklas 5.16.P-We297

Vargas, Nataly 6.05.T-03

Vargas, Rodrigo 2.06.P-Th114, 2.06.T-03

Vargas, Sofia 6.05.T-03

Varghese, Linso 2.06.T-04

Vasquez, Martice 6.02.P-Th112

Vaugeois, Maxime 1.03.T-02, 4.03.T-06, 5.08.P-Tu133, 5.08.P-Tu134, 5.15.P-Tu170, 5.18.P-We024

VAUTHIER, Maé 4.14.P-We179

Vautour, Nathanael 4.13.T-04

Veillard, Delphine 2.05.T-05

Veilleux, Éloïse 5.17.P-We259

Veith, Tamie L. 4.06.P-Tu215

Velasteguí-Arias, Alfonso 4.05.T-01

Velicogna, Jessica R. 1.14.T-03

Velicogna, Jessica 1.14.P-Tu227, 1.14.T-04

Venier, Marta 4.06.T-06

Vennekate, John 4.06.P-Tu218

Ventura-Reyes, Reyna 3.06.P-Tu115

Verdaguer, Ariadna 1.04.P-Th167

Verdi, Amir 4.06.P-Tu210

Verdonck, Frederik 2.01.P-Tu078, 4.23.T-02

Veres, Emma 1.09.T.B-03

Verhille, Mathieu 4.22.P-Th233

Verner, Marc Andre 7.10.P-Tu301

Verones, Francesca 8.01.T-02

Verreault, Jonathan 3.01.P-Th032, 3.03.P-Tu041, 3.07.P-Tu048, 3.07.P-Tu055, 3.07.T.B-02, 4.05.P-Th149

Verslycke, Tim 2.04.P-Tu101, 5.10.P-We150

Versteeg, Donald 5.14.T-06

Via, Christopher 4.21.P-Th151

Viaene, Karel 2.01.P-Tu078, 4.23.T-02

Viallon, Jérome 1.07.P-We097

Viau, Charles 5.04.P-We249

Vidyarthi, Sangeeta 4.15.T-06

Vieira, Denise 2.02.P-Th265

Vieira Da Silva, Caroline 6.05.T-03

Vigneault, Juliane 3.07.V-01

Vijayan, Mathilakath 2.10.P-We107

Vijayan, Matt (Mathilakath) 4.04.P-Th107

Villanueva-Vargas, Diego 2.02.P-Th280

Villella, Maria 1.02.P-We246

Villeneuve, Daniel 1.05.P-Th181, 1.05.P-Th182, 1.05.T-02, 1.05.T-03, 1.06.P-Th026, 1.06.T-05, 1.10.T-02, 4.19.P-We207, 5.06.P-We237

Villeneuve, Janice 4.23.P-Tu153, 4.23.T-06

Villion, Manuela 8.02.P-We257

Villuendas Garcia, Helena 1.09.T.B-02

Viola, Benjamin 3.03.P-Tu042

Viscioni-Wilson, Lance 4.04.T.B-01

Vitharana, Nipuni N 4.12.P-Tu254

Vitharana, Nipuni N. 4.07.T-01

Vivant, Marion 8.02.T-03

Vivet, Sarah 3.01.P-Th030

Vlaeminck, Karel 2.01.P-Tu078, 4.23.T-02

Vlahos, Penny 4.08.P-We030

Vo, Brianna 5.02.T.A-06

Vogl, Annabelle 4.26.T-05

Vogt, Anja 4.26.T-06

Vojta, Simon 3.02.P-We032, 4.05.T-06, 4.09.P-We069, 4.18.P-Tu275, 4.25.P-Th194, 5.10.P-We126

Volmar Claudio, Lady 2.10.P-We119

vom Berg, Colette 1.02.T-06, 7.08.P-Tu135

von Au, Clarissa 2.01.T.A-02

Vorburger, Christoph 2.01.P-Tu088

Voros, Craig 2.02.P-Th273

Vozenilek, Natasha 5.10.P-We140

Vrana, Branislav 4.16.V-01

Vrkljan, Kaylin 8.09.T-04

Vucurevich, Tara 4.22.P-Th234, 4.23.P-Tu147

Vulpe, Chris 1.04.P-Th168, 1.05.P-Th179

Vythalingam, Lavanya 2.01.T.B-03, 3.07.T.A-06

W

Wada, Shinpei 4.24.P-We236

Waddey, Taryn 4.10.P-Tu007

Wade, Alexandra 2.13.P-Th239, 4.18.P-Tu261, 4.18.P-Tu262

Wagman, Michael 3.07.T.B-05

Wagner, Louis 1.15.P-We199, 4.17.P-Tu245, 4.17.T-05, 4.18.P-Tu260

WAGNER, Mickaël 3.06.P-Tu110

Walecka-Hutchison, Claudia 2.02.P-Th258, 2.02.T-06

Walker, Melissa 2.01.P-Tu092, 3.08.P-Th052

Walker, Robert 4.08.P-We029

Wallington, Timothy 5.02.T.B-03

Wallis, Chris 1.10.T-06

Walsh, David 8.02.P-We257, 8.02.T-04

Walsh, Stephanie 2.03.P-Th015

Walshaw, Hazel 4.23.P-Tu158

Wambaugh, John 4.03.T-02

Wang, Cuili 5.09.V-01

Wang, Evelyn 4.07.P-Tu139, 5.17.P-We260

Wang, Feiyue 4.04.T.A-04

Wang, Jian 4.24.P-We221

Wang, Lixi 7.10.P-Tu301

Wang, Qianyang 4.23.P-Tu148

Wang, Shengnan 7.07.T-02

Wang, Stephanie 4.26.T-04

Wang, Wei 4.09.P-We076

Wang, Wenling 4.05.P-Th136, 4.26.P-Th284

Wang, Xiaowa 4.04.P-Th091

Wang, Xiaoyun 4.07.P-Tu141, 4.07.T-03, 4.19.T-04

Wang, Xiulan 4.02.P-Tu208

Wang, Zhanyun 7.07.T-02, 7.10.P-Tu301

Wang, Zihang 2.13.T-01

Wanger, Thomas 5.09.V-01

Wania, Frank 4.01.P-Th158, 4.01.T-04, 4.05.P-Th134, 4.06.P-Tu219, 4.19.P-We210, 4.24.P-We225, 4.24.T-01, 5.01.P-We061, 5.01.P-We063, 8.03.P-We005

Wanzek, Tom 4.02.T-04

Wardinski, Catherine 4.15.P-Tu174, 4.15.P-Tu178, 4.15.T-03, 4.27.T-02

Wardlaw, Colleen 2.10.P-We102, 4.22.T-06

Warlow, Erin 4.12.P-Tu257

Warner, Braedon 5.07.T-06

Warner, Kara 1.15.P-We203

Warriner, Theresa 1.02.T-01, 1.09.P-Tu128, 2.10.P-We106, 4.12.P-Tu258, 4.13.P-Th125, 5.04.P-We251

Watanabe, Haruna 2.03.P-Th006, 5.04.P-We247

Waters, Katrina 4.05.P-Th146, 4.10.T-03

Watkins, Shannon Lea 7.11.P-Tu305

Watt, Cortney 3.07.P-Tu048, 3.08.T-03, 4.04.T.B-05

Webb, Lisa 2.02.P-Th274

Webb, Sarah 4.02.P-Tu207, 6.03.P-Tu029

Weidemann, Eva 5.01.T-01

Weinstein, John 4.17.P-Tu236

Weiss, Christine 2.13.P-Th241

Weisse, Jillian 3.07.P-Tu054

Welch, Abi 4.04.P-Th098

Welch, Sam 2.01.P-Tu078

Wells-Carpenter, Alexis 6.03.P-Tu028

Welsh, Brittany 4.24.T-04

Weltje, Lennart 1.13.P-Tu036, 1.13.T-05, 2.02.P-Th255, 5.08.P-Tu129, 5.11.P-Tu165

Wenclawiak, Jessica 4.17.P-Tu236

Wentzel, Alyssa 2.07.P-We057

Wesley, Braide 6.03.P-Tu026

Wesner, Jeff 4.04.P-Th098, 4.23.P-Tu149

Wessel, Janel 2.13.T-05

Wexler, Anthony 1.10.T-06

Whaanga, Dean 5.07.T-02, 7.07.T-03

Wheeler, Helena 4.06.P-Tu213, 6.03.P-Tu029

Wheeler, James 1.13.P-Tu036, 1.13.T-03, 1.13.T-05

Wheelock, Craig 4.19.P-We208

Whicker, Jeffrey 4.13.P-Th127

Whipps, Christopher 5.02.P-We286

Whitcraft, Christine 1.14.P-Tu230

White, Jason 8.03.P-We003, 8.03.T-02

White, Sarah 2.13.P-Th246, 7.11.P-Tu303

Whitehead, Heather 4.01.T-02

Whitehead, Kenia 1.09.P-Tu117, 5.02.P-We273

Whitmire, Stefanie 2.03.P-Th008, 4.15.P-Tu177, 4.17.T-01

Whitmore, Kimberlee 4.04.P-Th090, 4.04.P-Th098, 4.04.T.B-01

Whittaker, Margaret 5.10.P-We139, 8.08.T-02, 8.08.T-05

Wicker, Joerg 5.06.T-02

Wicks, Alyssa 4.06.T-05

Widmer, Tasha 5.10.P-We143

Wight, Jeffrey 2.07.P-We048

Wijntjes, Christiaan 4.23.P-Tu158

Wiklund, Johan 4.16.T-04

Wilkes, Austin 4.14.P-We177

Wilkie, Michael 2.01.P-Tu091, 2.02.P-Th261

Wilkinson, Kevin 1.07.P-We085, 2.03.P-Th007, 3.08.T-01, 4.04.P-Th102, 4.15.P-Tu183, 4.18.P-Tu264

Willacker, James 2.12.P-We182

Williams, Brianna 2.04.T-05, 4.17.P-Tu241, 4.17.T-04

Williams, Jake 4.02.P-Tu208

Williams, Jarquees 7.05.P-We159

Williams, Kim 3.01.P-Th028

Williams, Lisa 3.07.T.A-01

Williams, Osianna 2.10.P-We116

Williams, Tristan 4.04.T.B-01

Williams, Tyler 4.04.T.B-01

Williard, Amanda 3.02.T-06

Willis, Mary 8.09.T-04

Willming, Morgan 5.14.T-02

Wilson, Abbey 4.04.P-Th105

Wilson, Angela 1.06.P-Th024

Wilson, Brandi 5.10.P-We143

Wilson, Iain 1.01.P-Tu010, 1.01.T-05, 5.14.T-03, 7.03.T-02

Wilson, Jared 5.02.T.A-04

Wilson, Joanna 1.02.P-We242, 1.04.P-Th170, 1.06.T-06, 1.07.P-We094, 1.09.P-Tu116, 2.03.T-04

Wilson, Kyle 4.04.P-Th107

Wilson, Mark 4.01.T-02

Wilson, Patrick 4.23.P-Tu161

Wilson, Sandra 4.23.P-Tu161

Wilson, Simon 4.04.T.A-04

Wilson-Fallon, Alexander 5.02.T.B-06

Winn, Louise 4.17.P-Tu250

Winny, Grace 5.02.T.A-06

Winter, Carley 2.08.P-Tu062

Wipfler, Louise 5.15.P-Tu166

Wirth, Ed 7.02.T-03

Wiseman, Steve 1.03.T-04, 5.06.T-04

Wnek, John 3.02.T-06

Wojichowski, Tyler 4.15.P-Tu187, 4.15.P-Tu188

Woke, Justice 4.07.T-02, 4.22.P-Th214

Wolf, Raoul 5.16.P-We290, 5.16.P-We291

Wolfram, Jakob 2.01.P-Tu089, 2.01.P-Tu090, 4.23.P-Tu149, 7.03.P-We084

Wong, Charles 2.05.T-06, 4.05.P-Th140, 4.05.T-02

Wong, Fiona 2.05.P-We043

Wong, Jordan 4.04.P-Th096, 4.04.P-Th097

Wong, Luann 4.10.T-05, 4.19.T-06, 4.21.P-Th147, 4.21.T-06

Wood, Chris M. 2.08.P-Tu063

Wood, Chris 2.08.P-Tu062, 5.06.T-04

Woodbury, Lynn 4.14.P-We181

Woodlief, Tracey 1.08.P-We171

Woodward, Melissa 4.05.T-06, 4.18.P-Tu275

Woodyard, Megan 6.01.T-02

Wooliever, Eli 1.07.P-We090

Wootton, Eric 3.08.T-05

Word, Jack (Jay) 2.01.P-Tu072, 5.10.P-We134

Woudneh, Million 4.01.P-Th160, 4.05.T-04

WOZNIAK, BEN 1.15.P-We201

Wray, Austin 5.08.P-Tu130

Wright, David 4.04.T.B-01

Wu, Chia-Chen 5.02.T.A-06

Wu, Langping 4.13.T-01

Wu, Lisa 7.02.P-Th207

Wu, Meiqun 4.04.P-Th104

Wu, Meng-Chun 2.10.P-We122

Wu, Mong Sin Christine 4.22.P-Th232

Wunderley, Andrew 7.02.T-03

X

Xia, Chunjie 4.06.T-06

Xia, Jianguo 5.04.P-We249, 8.08.P-Tu309

Xia, Xin-Rui 4.05.P-Th136, 4.26.P-Th284

Xia, Xiomeng (Kate) 5.17.P-We260

Xia, Zhe 1.03.T-04

Xia, Zhiyong 5.09.P-Tu293

Xiang, Tongtong 4.08.P-We025

Xie, Huixiang 4.24.P-We228

Xie, Jiacheng 6.01.T-03

Xu, Dong 6.01.T-03

Xu, Jiaqi 1.02.T-04

Xu, Ke 1.05.P-Th180, 1.05.P-Th183, 1.05.T-05, 1.08.P-We168, 1.09.P-Tu120, 1.09.T.A-05, 1.09.T.A-06, 1.09.T.B-03, 4.03.P-Th164, 4.07.T-04, 8.08.P-Tu309

Xu, Shihe 4.04.T.A-03

Xu, Tongfei 8.01.T-06

Xu, Xiaoyu 3.02.P-We036, 4.05.P-Th138

Xuereb, Benoit 2.01.P-Tu068

Y

Yabuki, Yoshinori 4.02.P-Tu203, 4.22.P-Th226

Yaddehige, Sithumi 4.04.P-Th095

Yamagishi, Takahiro 5.04.P-We247

Yamamoto, Hiroshi 2.03.P-Th006, 5.04.P-We247

Yamamoto, Mei 2.10.P-We109

Yamane, Masayuki 2.07.P-We052

Yamasaki, Masatoshi 1.05.P-Th184, 2.02.P-Th271, 2.07.P-We054, 3.07.P-Tu058, 4.09.P-We071, 4.17.P-Tu235, 4.24.P-We236

Yameni Kakoua, Leon Crepin 5.02.P-We278

Yan, Yan 5.09.V-01

Yang, Cindy X. 4.17.P-Tu237

Yang, Diwen 4.07.T-03, 4.09.T-06

Yang, Gaeul 5.06.P-We238

Yang, Gary 2.13.P-Th238

Yang, Haoran 4.06.T-03, 5.17.P-We261

Yang, Lingling 2.06.T-04

Yang, Nuen Tsang 4.19.T-06

Yang, Shih-Hung 4.27.T-03

Yang, Sung Ik 4.15.P-Tu186

Yang, Sungik 4.18.P-Tu282

Yang, Tao 4.19.T-04

Yang, Yang 1.04.P-Th168

Yannou, Bernard 8.04.P-Tu016

Yao, Kaiqi 4.17.P-Tu232, 4.17.P-Tu237

Yaoyu, Li 2.01.T.A-03

Yargeau, Viviane 4.01.T-03

Ye, Jingyun 4.18.P-Tu270, 4.22.P-Th235

Ye, Meng Wei 4.04.P-Th104

Ye, RenXi 4.25.T-05

Yeung, Kirsten 4.19.P-We210

Yi, Seung-Muk 1.10.P-We302

Yin, Ge 4.17.P-Tu231

Yoder, Jeff 1.08.P-We173

Yohannes, Yared 3.08.P-Th043

Yokoyama, Saichiro 3.07.P-Tu058

Yonkos, Lance 2.01.T.B-06, 7.02.P-Th206

Yoshitake, Koji 2.10.P-We118, 7.04.T-05

You, Yarina 8.02.T-06

Young, Brian Jonathan 1.04.P-Th167

Young, Cora 4.10.P-Tu006, 4.10.T-01, 4.25.P-Th192, 4.25.T-03, 4.25.T-05, 4.25.T-06

Young, Dirk 5.08.P-Tu130

Young, Robert 3.07.P-Tu050

Young, Taylin 2.01.T.B-01

Young, Thomas 2.02.T-03, 4.10.T-05, 4.19.T-06, 4.21.P-Th147, 4.21.T-03, 4.21.T-06, 4.23.P-Tu151

Young, Tom 4.06.P-Tu210

Yousefi, Aida 4.21.P-Th152

Ysabelle Rodrigo, Aryenne 4.10.T-02

Yu, Maria 4.13.T-06

Yu, Minseo 1.06.P-Th025

Yu, Shuo 2.07.T-06, 3.08.P-Th033

Yu, Xue 4.08.P-We030

Yuan, Bo 3.08.P-Th046, 4.17.P-Tu231

Yuan, Jing 8.03.P-We003

Yun, Kijeong 1.07.P-We089

Z

Zabel, Fiona Quin 4.08.P-We030

Zahn, Sarah M. 2.04.P-Tu101

Zajac-Fay, Rachel 4.05.T-05, 5.02.T.A-01

Zakharov, Kirill 5.10.P-We129, 5.10.P-We138

Zaky, Yaseen 4.04.P-Th099

Zalouk-Vergnoux, Aurore 2.07.P-We056, 2.07.T-02

Zambakjian, Celine 4.02.P-Tu205

Zambrano, Ricardo 4.05.T-01

Zanrré Magalhães, Pedro 2.10.P-We113

Zareifi, Danae 5.02.T.A-05

Zeeb, Barb 3.06.T-03

Zeeb, Barbara 3.06.T-02

Zeng, Quan 8.03.T-02

Zeng, Siyan 5.09.V-01

Zenobio, Jenny 5.02.P-We272

Zetterholm, Linda 4.04.P-Th087

Zhan, Faqiang 4.05.P-Th134

Zhan, Jing 5.01.P-We065

Zhang, Annabel 4.01.T-06

Zhang, Bing 4.15.P-Tu182

Zhang, Pinbo 5.17.P-We260

Zhang, Shaohan 1.13.P-Tu040

Zhang, Shuqing 4.24.T-05

Zhang, Xianming 1.02.T-05, 4.01.P-Th158, 4.01.P-Th159, 4.21.P-Th152, 5.06.T-05, 5.10.P-We133, 8.03.P-We006

Zhang, Xiaoyu 4.04.P-Th106

Zhang, Xinxin 5.09.V-01

Zhang, Yanan 1.09.P-Tu123

Zhang, Yang 4.15.P-Tu182

Zhang, Yanyan 5.09.V-01

Zhang, Ziqi 4.24.T-01, 5.01.P-We063

Zhao, Jian 4.14.P-We176

Zhao, Tim 2.01.P-Tu091

Zhao, Xin 5.04.P-We249

Zhou, Guangyan 8.08.P-Tu309

Zhou, Jie 1.04.P-Th168

Zhu, Yumin 4.10.T-02

Zielinski, Moriah 1.02.T-04

Zilkey, David 2.01.T.B-02

Zink, Lauren 2.08.P-Tu063, 5.06.T-04

Zinsser, Lauren 1.15.P-We205, 1.15.T-03, 1.15.T-06, 2.05.T-03

Zodrow, Jean 3.08.P-Th034, 5.02.P-We272

Zorrilla, Leah 5.05.P-We012

Zou, Shan 4.15.P-Tu190

Zubrod, Jochen 1.03.T-02

Zuverza-Mena, Nubia 4.21.T-04, 8.03.P-We003, 8.03.T-02

Affiliation Index

•

. 3.08.P-Th045

1

1 Department of Civil, Geological and Mining Engineering, Polytechnique Montréal, 2500 Chemin de Polytechnique, Montréal, QC H3T 1J4, Canada / 2 Université de Savoie Mont-Blanc, France 4.23.P-Tu157

1 Department of Civil, Geological and Mining Engineering, Polytechnique Montréal, 2500 Chemin de Polytechnique, Montréal, QC H3T 1J4, Canada / 4 Geotop, Canada 4.23.P-Tu157

1. Department of Microbiology, University of Port Harcourt; 2. Department of Environmental Sciences, University of South Africa (UNISA) 6.05.V-02, 6.05.V-03

1. University of Port Harcourt (UniPort), Nigeria. 2. University of South Africa (Unisa) 4.18.V-01

1Department of Microbiology, Hezekiah University, Umudi,Imo state Ngeria 6.03.P-Tu026

2

2Department of Microbiology, Federal University of Technology, Owerri, Nigeria 6.03.P-Tu026

3

3 Department of Earth and atmospheric sciences, Université du Québec à Montréal, University of Quebec in Montreal (UQAM), Canada / 4 Geotop, Canada 4.23.P-Tu157

3Department of Plant, Food, and Environmental Sciences, Dalhousie University, Canada 6.03.P-Tu026

A

Aarhus University 3.08.T-03, 5.02.P-We288

Abia State University 8.06.V-01

Abia State University, Uturu 3.06.P-Tu106, 6.05.T-05

Acadia University 4.26.P-Th281, 4.26.P-Th283

Acadia University, Department of Biology 2.07.P-We055

Acadia University, Department of Earth and Environmental Science 2.07.P-We055

Active Earth 3.07.P-Tu053

ADAMA Agricultural Solutions 5.10.P-We145

ADAMA Agriculture Germany 1.13.T-05, 5.15.P-Tu168

ADEPT Environmental Sciences Ltd 1.15.T-02

ADEPT Environmental Sciences Ltd. 1.15.P-We198, 1.15.P-We203

AECOM 2.14.P-We197, 5.10.P-We140

Agence Mamu Innu Kaikusseht 2.01.P-Tu081

Agency of Industrial Science and Technology 4.24.P-We232

Agilent Technologies 4.07.P-Tu140

Agilent Technologies Inc. 4.06.P-Tu214, 4.07.P-Tu140

Agilent Technologies, Inc. 4.06.P-Tu214, 4.15.P-Tu182

Agriculture and Agri-Food Canada 4.23.P-Tu152

Agriculture and Agri-Food Canada (AAFC) 4.22.P-Th234, 4.23.P-Tu147, 4.25.P-Th191

Ahtna Intertribal Resource Commission 4.04.P-Th105

Air Quality Processes Research Section, Environment and Climate Change Canada 4.04.P-Th093

Air Quality Research Center and College of Engineering, UC Davis 1.10.T-06

Air Quality Research Center, University of California Davis 1.10.T-06

Airway BioCore, Marsico Lung Institute, The University of North Carolina, Chapel Hill, NC 1.08.P-We172

Akvaplan NIVA 3.08.T-03

Alaska Cooperative Fish and Wildlife Research Unit, U.S. Geological Survey, Fairbanks, AK 4.23.P-Tu149

Alaska Department of Fish and Game 4.04.P-Th092, 4.04.P-Th105

Alcoa Corporation 4.14.P-We177

Alexandria University 1.02.V-01

Algoma University 7.07.T-01

Alma College 2.08.P-Tu064, 2.08.P-Tu065, 2.08.P-Tu066

ALS 4.02.P-Tu199

ALS Environmental Canada 1.15.P-We199, 4.17.P-Tu245, 4.17.T-05, 4.18.P-Tu260

ALS Global 4.06.P-Tu211, 5.02.P-We271

ALS Laboratories 4.06.P-Tu211, 5.02.P-We271

Amaroq Wildlife Services 3.07.P-Tu052

Anacostia Watershed Society 7.02.P-Th206

Anchor QEA 2.05.P-We043

Anchor QEA LLC 2.05.P-We043, 4.12.P-Tu257

Andreas Aronsson Consulting AB 1.01.T-05, 2.02.P-Th276, 2.02.P-Th277

Anglian Water 1.01.T-04

Animal Health Centre, BC Ministry of Agriculture, Food and Fisheries, Abbotsford, BC, Canada. 3.08.P-Th039

Ann and Robert H. Lurie Children's Hospital, Chicago, IL 5.04.T-01

Ann and Robert H. Lurie Children's Hospital, Chicago, IL; Department of Pediatrics, Feinberg School of Medicine, Chicago, IL 5.04.T-01

Applied Pharmacology and Toxicology, Inc. 7.12.T-05

Aquablok 6.03.P-Tu027

AquaBlok 6.03.P-Tu027

Aquatic Animal Health Research Unit, U.S. Department of Agriculture - Agricultural Research Service, Auburn, AL 36832, USA 1.08.P-We166

aQuaTox-Solutions GmbH 1.09.T.B-02

ARC Arnot Consulting & Research 4.09.P-We072

ARC Arnot Research & Consulting 1.09.P-Tu127

Arcadis 1.01.P-Tu011, 3.02.P-We033, 3.04.P-We309

ARCHE Consulting 2.01.P-Tu078, 4.23.T-02

Arctic Centre, Canadian Museum of Nature 4.04.T.B-06

Arctic Monitoring and Assessment Programme 4.04.T.A-04

Arkansas State University 4.02.P-Tu207, 6.03.P-Tu029

Armand-Frappier Santé Biotechnologie Research Centre, Institut National de la Recherche Scientifique 4.01.P-Th158

Armitage Environmental Sciences Inc. (AES) 1.09.P-Tu122

Arnot Research & Consulting (ARC) 1.09.P-Tu122, 4.03.T-03, 4.04.P-Th086, 4.22.P-Th230, 5.01.P-We059, 5.01.P-We060, 5.01.T-04

Ashland High School 6.05.V-01

Auburn Univeristy 2.03.T-05

Auburn University 2.03.T-05, 4.15.P-Tu188, 7.05.P-We155

Auburn University; U.S. Geological Survey 4.15.P-Tu188

Augustana Campus, Camrose, University of Alberta 4.14.P-We178

Augustana College 4.04.P-Th098

Australian Institute of Marine Science 3.03.P-Tu042, 5.16.P-We298

Austrian Agency for Health and Food Safety (AGES) 5.08.P-Tu129

Autoridad Regulatoria Nuclear 4.13.P-Th127

AxNano 6.03.P-Tu028

Azimuth Consulting Group Inc. 1.01.P-Tu012, 2.02.P-Th269, 2.12.P-We186, 2.13.P-Th239, 5.16.T-02

B

Bakker Onderzoeks Beheer 5.15.P-Tu167

Barnstable County, MA 5.09.P-Tu288

Barr Engineering 5.02.P-We289

Barr Engineering Co. 1.01.T-02, 1.15.P-We198, 5.02.P-We289

BASF Agricultural Solutions 2.02.P-Th255, 5.11.P-Tu165, 7.03.T-04

BASF Agricultural Solutions Deutschland 2.02.P-Th255, 5.11.P-Tu165

BASF Agricultural Solutions US LLC 3.06.P-Tu107, 3.08.P-Th047

BASF Corporation 1.13.T-05

BASF France S.A.S. 5.15.P-Tu168

BASF SE 1.13.P-Tu036, 1.13.T-05, 3.06.T-06, 5.08.P-Tu129, 5.18.P-We021

BASIS Chandler High School 6.05.P-Th200

Battelle Memorial Institute 1.13.P-Tu034

Bavarian Environment Agency, Augsburg 4.09.T-05

Bayer AG 5.15.P-Tu168

Bayer AG Crop Science Research & Development 1.13.T-05, 5.08.P-Tu132

Bayer AG CropScience Division 3.06.T-06

Bayer AG, Crop Science Division, Environmental Safety 1.13.T-03

Bayer Crop Science 5.18.P-We023

Bayer CropScience 1.13.T-03

Bayer Research & Development Services LLC 1.06.P-Th027, 1.13.P-Tu036, 1.13.T-05, 5.05.P-We011, 5.05.P-We012, 5.08.P-Tu129, 5.18.P-We022

Bayer US Holding LP 5.18.P-We023

Baylor University 1.02.P-We245, 2.01.P-Tu084, 5.02.P-We269, 6.01.T-02, 8.03.T-01

Bigelow Laboratory for Ocean Sciences 2.06.T-04

Biodiversity Research Institute (BRI) 2.10.P-We107, 6.02.P-Th108

Biodiversity Research Institute (IMIB), University of Oviedo–CSIC–Principality of Asturias, Mieres, Asturias 4.23.P-Tu149

Bioeconomy Science Institute 7.07.T-03, 8.01.T-03

Biologist, Environmental Health Science and Research Bureau, Health Canada, Ottawa, Ontario, Canada 1.07.P-We091

Biology Department, Acadia University 3.04.P-We308

Biology Department, York University, 4700 Keele Street, Toronto, ON M3J 1P3, Canada 2.02.T-01

BIOMAE, Groupe Carso, 01500 Château-Gaillard, France. 2.01.P-Tu068

Bioresearch & evaluation 5.15.P-Tu167

Blankinship & Associates Inc. 5.16.P-We296

BLM 2.14.T-03

Bocock Chair for Agriculture and the Environment, Department of Renewable Resources, University of Alberta 4.14.P-We178

Boliden 1.01.T-05, 2.02.P-Th276, 2.02.P-Th277

Borealis Environmental Consulting Inc. 1.01.P-Tu012

Boston University School of Public Health 8.09.T-04

Bowdoin College 4.09.P-We073, 4.09.P-We074, 4.09.P-We075

Bowman Consulting Group 1.09.T.A-04

BQE Water 1.15.T-05

BQE Water Inc. 1.15.P-We198

Brazilian Agricultural Research Corporation (Embrapa) 5.11.P-Tu163

Bren School of Env. Sci. and Man., University of California, Santa Barbara, Santa Barbara, CA, USA. 4.06.P-Tu210

British Columbia Institute of Technology 2.13.P-Th238, 4.17.T-03

British Columbia Institute of Technology (BCIT) 2.08.P-Tu062

British Columbia Intitute of Technology 4.17.T-03

Broadwing Biological Consulting 3.01.P-Th028, 3.07.T.A-02

Brooks Applied Labs, LLC 1.15.P-We201

Brunel University 5.08.P-Tu129

BST Consulting, LLC 3.02.P-We033

Bulgaria Antarctic Institute 4.04.T.A-03

Bureau du forestier en chef 8.04.P-Tu015

C

Ca' Foscari University of Venice 8.03.T-02

California Department of Fish and Wildlife, Office of Spill Prevention and Response 6.02.P-Th112

California Department of Toxic Substances Control (DTSC) 8.08.T-02

California State University 5.02.T.B-03

California State University Long beach 1.14.P-Tu230

California State University Long Beach 1.14.P-Tu230

California State Water Resources and Control Board 8.05.P-We217

California State Water Resources Control Board 1.01.T-02, 2.02.T-03, 4.21.T-03, 4.23.T-04

Calvin University 3.07.T.A-01, 3.08.T-06

Calvin University and Wings Over Water Research Institute 3.07.T.A-01, 3.08.T-06

Canadian Forest Service Department, Natural Resources Canada 3.04.P-We308

Canadian Light Source 1.08.P-We168

Canadian Light Source, Saskatoon, SK S7N 2V3, Canada 4.24.P-We221

Canadian Nuclear Laboratories 2.03.P-Th015

Canadian Nuclear Laboratories (CNL) 1.01.T-03, 1.05.P-Th178, 4.13.T-03

Canadian Nuclear Laboratories, Chalk River, Ontario 1.05.P-Th178

Canadian Nuclear Safety Commission 4.13.P-Th127, 4.13.T-02, 4.13.T-06

Canadian Wildlife Health Cooperative, Département de sciences Clinique, Faculté de médecine vétérinaire[SL1.1], Université de Montréal, Saint-Hyacinthe, QC, Canada 3.03.P-Tu041

Canadian Wildlife Health Cooperative, Faculté de médecine vétérinaire, Université de Montréal, Saint-Hyacinthe, Québec, J2S 8H5, Canada 3.07.P-Tu048

Canadian Wildlife Service, Environment & Climate Change Canada 3.07.T.B-01

Canmet-MINING, Natural Resources Canada, Ontario, Canada 4.13.P-Th123

CanmetENERGY, Natural Resources Canada 8.04.P-Tu015

Carbon Neutral Society Promotion Division, Saga Prefectural Government, Japan 2.10.P-We118, 7.04.T-05

Carleton University 1.02.P-We240, 1.14.T-03, 1.14.T-04, 2.03.P-Th007, 2.10.P-We108, 4.18.P-Tu271, 4.21.P-Th151, 6.05.T-02

Carleton University - Biology Department 4.04.P-Th095, 4.04.P-Th097

Carleton University, Biology Department 4.04.P-Th096

Carnegie Mellon University 3.07.P-Tu045, 4.19.T-02

Castrol Limited 1.13.P-Tu039

Catalan Institute for Water Research (ICRA) 5.14.T-06

CDFW-OSPR 3.03.P-Tu043

CDM Smith 4.14.P-We181

CEAEQ, MELCCFP 4.01.T-01, 4.02.P-Tu193

CEMC Trent University 5.14.P-Th197

Center for Environmental Toxicology and Health (TOXEN), Département des Sciences Biologiques, Université du Québec à Montréal, Montreal, QC, Canada 3.03.P-Tu041

Center for Health and the Environment & School of Veterinary Medicine, University of California Davis 1.10.T-06

Center for Health and the Environment, UC Davis 1.10.T-06

Center for Marine Environmental Studies, Ehime University 2.10.P-We109

Center for Molecular Medicine (CMM), Karolinska University Hospital 4.19.P-We208

Center for Oil and Gas Development 4.04.P-Th095

Center for Research in Advanced Materials, S.C. (CIMAV) 4.07.V-01

CentraleSupélec, Université Paris-Saclay 8.04.P-Tu016

Centre d'Études Biologiques de Chizé (CEBC), CNRS, Villiers-en-Bois, France. 3.08.P-Th044

Centre d'expertise en analyse environnementale du Québec 1.05.P-Th185, 4.15.P-Tu184

Centre d'expertise en analyse environnementale du Québec (MELCCFP) 4.05.T-03

Centre d’expertise en analyse environnementale du Québec (MELCCFP) 4.05.T-03

Centre d’expertise en analyse environnementale du Québec, ministère de l’Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs, Québec, QC, Canada. 4.22.T-04

Centre d’expertise en analyses environnemental du Québec (CEAEQ), Ministère de l’Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs (MELCCFP) 2.14.P-We189

Centre de Recherche sur La Biodiversité et L’Environnement (CRBE), Université de Toulouse, CNRS, IRD, Toulouse INP, Université Toulouse 3 – Paul Sabatier (UT3), Toulouse, France 8.02.T-03

Centre for Fish and Wildlife Health, University of Bern 1.07.P-We088

Centre for Functional and Metabolic Mapping, Robarts Research Institute, Western University, London, ON N6A 5K8, Canada 2.02.T-01

Centre for Oil and Gas Research and Development 4.04.P-Th096, 4.04.P-Th097

Centre for Oil and Gas Research and Development (COGRAD), Department of Chemistry, University of Manitoba, Winnipeg, Manitoba 4.12.P-Tu254

Centre for Oil and Gas Research and Development (COGRAD), Department of Chemistry, University of Manitoba, Winnipeg, MB R3T 2N2 4.07.T-01

Centre Hospitalier Universitaire de Sherbrooke, Sherbrooke & CHU Sainte-Justine, Montreal, QC, Canada 5.10.P-We128

Centre of Toxicology, University of Saskatchewan 2.02.P-Th252, 4.24.T-04

Centro de Investigación en Contaminación Ambiental (CICA), Universidad de Costa Rica, 2060, San José, Costa Rica. 5.14.P-Th198

Centro de Investigación en Química, Toxicología y Biotecnología Ambiental, Departamento de Química, Facultad de Ciencias, Universidad Nacional Agraria La Molina, 15024, Lima, Perú. 5.09.V-01

Centro de Investigaciones en Geografia Ambiental - Universidad Nacional Autónoma de México 7.04.V-01

CEROM 4.23.P-Tu152

Charles Dale Memorial International School (CDMIS), Port Harcourt, Rivers State 4.18.V-01

Charleston Waterkeeper 7.02.T-03

Charted Marine Consulting; Galveston Bay Dolphin Research Program 3.07.P-Tu050

Chem. and Env. Eng. Dept., University of California, Riverside, Riverside, CA, USA. 4.06.P-Tu210

ChemFORWARD 8.08.P-Tu308, 8.08.T-02, 8.08.T-04

Chemical Insights Research Institute a unit of UL Research Institues 4.01.T-02

Chemistry Department, Kwame Nkrumah University of Science and Technology, Kumasi 4.23.P-Tu160

Chemistry Department, Kwame Nkrumah University of Science and Technology, Kumasi. 4.23.P-Tu160

Chemistry Matters Inc., Calgary, Alberta, T2N 3P7 4.07.T-01

Chemours Company 4.21.P-Th153

Cherokee Nation System Solutions in support of U.S Geological Survey, Wetland and Aquatic Research Center 3.08.P-Th040

Chimie, Universite de Montreal 6.03.P-Tu025

China Agricultural University 5.01.P-We065

China National Center for Food Safety Risk Assessment 5.01.P-We065

Chiron K9 2.06.P-Th115

Chonnam National University 5.10.P-We135, 5.10.P-We137

CIAPE-ICEDA (INRS) 7.04.T-01

CIRAIG Polytechnique Montreal 8.01.T-01

Citadel 4.17.P-Tu236

City of Calgary 4.27.T-06

Civil Engineering department, McGill University 8.03.T-05

Clarkson University 3.07.P-Tu045

Clayton H. Riddell Faculty of Environment, Earth, and Resources, University of Manitoba 4.04.P-Th093

Clemson University 2.01.P-Tu092, 2.03.P-Th008, 2.10.P-We123, 2.13.P-Th246, 3.08.P-Th052, 4.13.P-Th126, 4.13.P-Th127, 4.13.T-05, 4.15.P-Tu177, 4.17.T-01, 7.11.P-Tu303

CNRS 3.06.T-05

CNRS - GET 3.06.P-Tu110

Coastal Carolina University 3.07.P-Tu050

College of Charleston 3.07.P-Tu050, 4.15.P-Tu177, 4.17.P-Tu236, 4.17.T-01, 4.24.P-We233

College of Environmental and Resource Sciences, Zhejiang University, Hangzhou, Zhejiang 310058, China; Key Laboratory of Coastal Environment and Resources of Zhejiang Province, School of Engineering, Westlake University, Hangzhou, Zhejiang 310030, China 5.09.V-01

College of Oceanography and Ecological Science, Shanghai Ocean University 4.17.P-Tu231

College of the Atlantic 4.02.T-01

College of the Environment, Western Washinton University 5.16.P-We294

College of William & Mary 4.15.P-Tu174, 4.15.P-Tu178

Colorado Parks and Wildlife 2.01.T.A-05, 2.10.P-We107

Colorado School of Mines 4.09.T-01

Colorado State University 2.01.T.A-05

Community Science Institute 4.23.P-Tu150

Compliance Services International (CSI) 5.18.P-We021, 5.18.P-We022

Concordia 4.01.P-Th159

Concordia Univeristy 5.10.P-We133

Concordia University 1.02.T-05, 1.14.T-06, 4.01.P-Th158, 4.01.P-Th159, 4.21.P-Th152, 5.06.T-05, 5.10.P-We133, 8.02.P-We257, 8.02.T-04, 8.03.P-We006

Conicet 3.01.P-Th029, 4.11.P-We161

Connecticut Agricultural Experiment Statiom 4.06.T-03

Connecticut Agricultural Experiment Station 4.02.P-Tu197, 4.06.T-03, 4.21.T-04, 5.17.P-We261, 8.03.P-We003, 8.03.P-We009, 8.03.T-02

Connecticut Agricultural Experiment Station, New Haven, CT 06511, USA 8.03.P-We003

Connecticut Agriculture Experiment Station 2.07.P-We047

Conservancy of Southwest Florida 3.02.T-02

Conservation International 4.05.T-01

Consolidated Safety Services (CSS) 4.17.P-Tu236

Consultant 3.08.T-06

Copper Alliance 1.01.P-Tu010

Copperhead Environmental Consulting Inc. 5.02.T.B-04, 5.10.P-We149

Cornell University 4.09.T-01, 4.09.T-03

Corteva 3.02.T-04, 5.15.P-Tu167

Corteva Agricscience UK Limited 2.03.P-Th014

Corteva Agriscience 1.02.T-04, 1.13.T-03, 5.10.P-We145, 5.11.P-Tu162, 5.11.P-Tu164, 5.16.P-We292, 5.18.P-We019, 5.18.P-We020

Corteva Agriscience Germany GmbH 4.23.P-Tu158

Corteva Agriscience LLC 4.23.P-Tu158, 5.05.P-We017

Corteva Agriscience UK Limited 2.03.P-Th014, 4.23.P-Tu158

Corteva Agriscience UK Limited. 1.13.P-Tu036, 1.13.T-03, 1.13.T-05, 2.03.P-Th014, 3.06.T-06, 5.05.P-We017, 5.11.P-Tu163, 5.11.P-Tu164, 5.18.P-We020

Corteva Agroscience 5.05.P-We012

Cosmetics Alliance Canada 1.09.T.B-02

Council for Scientific and Industrial Research 4.18.V-02

Covestro Deutschland AG 4.24.P-We230

Cowichan Tribes 5.07.T-05

Crane Trust 3.07.T.B-01

Crocodile Research Coalition 3.02.P-We033

Croda International Plc 1.09.T.B-02

CSIR 4.11.P-We164

Czech University of Life Sciences Prague 5.10.P-We153

Czech University of Life Sciences, Prague 5.10.P-We153

D

Damina AB 4.04.P-Th087

Dartmouth College 2.12.P-We187

Deakin University 3.07.V-01

DECOD (Ecosystem Dynamics and Sustainability), L'Institut Agro 2.01.T.B-04

Defense Research and Development Canada 4.04.P-Th104

Delaware River Basin Commission 4.02.T-05

Delaware River Basin Commission (DRBC) 4.02.T-05, 4.05.T-06

Denali National Park and Preserve 4.04.P-Th105

Departamento de Biología de la Conservación y Cambio Globa, Estación Biológica de Doñana, Consejo Superior de Investigaciones Científicas (EBD-CSIC), Sevilla 1.03.P-Th019

Département de biologie - Université de Moncton 4.13.T-04

Département de Biologie, Chimie et Géographie, Université du Québec à Rimouski 2.01.P-Tu081

Departement de Biologie, Université Laval, 1045 Avenue de la Médecine, G1V 0A6 Québec, Canada 4.04.P-Th103

Département de chimie et biochimie - Université de Moncton 4.13.T-04

Département de Chimie, Université de Montréal, Montréal, QC 4.22.T-04

Departement de Chimie, Université Laval, 1045 Avenue de la Médecine, G1V 0A6 Québec, Canada 4.04.P-Th103, 4.24.P-We224

Department of Pharmacology/Toxicology, Faculty of Pharmaceutical Sciences, Abia State University, Uturu, Nigeria 5.10.P-We151

Department of Agricultural & Biological Engineering, The Pennsylvania State University, University Park, Pennsylvania & 5. Institute for Sustainable Agricultural, Food and Environmental Science, College of Agricultural Sciences, The Pennsylvania State University, University Park, Pennsylvania 4.06.P-Tu215

Department of Animal Science, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt 3.04.V-01

Department of Biochemistry, Faculty of Biological Sciences, Abia State University, Uturu, Nigeria 5.10.P-We151

Department of Biological Science and Technology, National Pingtung University of Science and Technology, Pingtung, Taiwan. 2.10.P-We122

Department of Biological Sciences, Ohio University, Athens, OH 3.02.T-06

Department of Biology and Marine Biology, University of North Carolina Wilmington, Wilmington, NC

3.02.T-06

Department of Biology, Hofstra University, New York, NY 3.02.T-06

Department of Biology, Queen's University, 116 Barrie Street, Kingston, Ontario, K7L 3N6, Canada 4.24.P-We224

Department of Biology, University of Aveiro, 3810-193 Aveiro, Portugal 1.04.P-Th167

Department of Biology, University of Ottawa, Ottawa, ON 1.09.P-Tu125

Department of Biomedical Science and Environmental Biology, Kaohsiung Medical University, Kaohsiung, Taiwan 2.01.P-Tu077

Department of Biomedical Sciences, Colorado State University 1.07.P-We093

Department of Biomedical Sciences, University of Padova, Padova, Italy 1.10.T-05

Department of Chemical Engineering, McGill University, Quebec, Canada, H3A 0C5 4.22.P-Th233

Department of Chemical Sciences, University of Padova, Padova, Italy 1.10.T-05

Department of Chemistry & Chemical Biology, McMaster University 4.21.P-Th150

Department of Chemistry and Biochemistry, Institute of Environment, Florida International University 4.27.P-We300

Department of Chemistry and Biochemistry, Missouri State University, Springfield, Missouri 65897 5.02.P-We274

Department of Chemistry, Christ University, Hosur Road, Bengaluru 560029, India 4.24.P-We221

Department of Chemistry, Faculty of Physical Sciences, Asia State University, Uturu, Nigeria 5.10.P-We151

Department of Chemistry, Université Laval 2.14.P-We189

Department of Civil & Environmental Engineering, Northwestern University, Evanston, IL 5.04.T-01

Department of Civil and Environmental Engineering, Florida International University 4.27.P-We300

Department of Civil and Environmental Engineering, Monash University, Melbourne 1.12.P-Tu226

Department of Civil Engineering, Lassonde School of Engineering, York University, Toronto, Canada 4.15.P-Tu185

Department of Climate Change, Energy, the Environment and Water (DCCEEW) 1.01.T-05, 2.02.P-Th276, 2.02.P-Th277, 3.03.P-Tu042

Department of Community and Ecosystem Ecology, Leibniz Institute of Freshwater Ecology and Inland Fisheries (IGB), Berlin 4.23.P-Tu149

Department of Construction Engineering, École de technologie supérieure, Québec, Canada, H3C 1K3 4.22.P-Th233

Department of Convergence Medical Sciences and Biomedical Research Institute, Pusan National University, Yangsan, Korea 1.08.V-01, 1.08.V-02

Department of Convergence Medical Sciences and Biomedical Research Institute, Pusan National University, Yangsan, Korea, Department of Obstetrics and Gynecology and Biomedical Research Institute, College of Medicine, Pusan National University, Pusan National University, Busan, Korea 1.08.V-02

Department of Earth and Environment, Institute of Environment, Florida International University 4.27.P-We300

Department of Earth, Ocean, and Atmospheric Sciences, University of British Columbia 4.26.T-04

Department of Environmental and Radiological Health Sciences, Colorado State University 1.07.P-We093

Department of Environmental Engineering and Science, National Pingtung University of Science and Technology, Pingtung, Taiwan. 2.10.P-We122

Department of Environmental Engineering, Texas A & M University-Kingsville 2.07.P-We057

Department of Environmental Health Sciences, Graduate School of Public Health, Seoul National University 5.09.P-Tu297

Department of Environmental Health Sciences, Graduate School of Public Health, Seoul National University, Seoul, Republic of Korea 5.09.P-Tu297

Department of Environmental Health, Yongin University 1.06.P-Th023

Department of Environmental Health, Yongin University, Republic of Korea 1.06.P-Th021

Department of Environmental Science, Baylor University, Waco, TX 6.01.T-02

Department of Environmental Science, Faculty of Natural Resources and Marine Science, Tarbiat Modares University 2.07.P-We053

Department of Environmental Sciences, College of the Environment, Western Washington University 2.01.T.A-06

Department of Estate Management, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt 3.04.V-01

Department of Fisheries and Oceans 4.04.P-Th094

Department of Fisheries and Oceans Canada 4.04.T.B-05

Department of Fisheries and Oceans Canada (DFO) 2.08.P-Tu062

Department of Geography, Geomatics and Environment - University of Toronto Mississauga 2.14.T-05

Department of Geography, Geomatics and Environment - University of Toronto Mississauga Canada 2.14.T-05

Department of Gynecology and Obstetrics, McMaster University, Hamilton, ON, Canada 2.06.P-Th114, 2.06.T-03

Department of Industrial Chemistry, University of Agriculture and Development Studies, Iragbiji, Osun State 5.10.P-We131

Department of Mechanical Engineering, Lassonde School of Engineering, York University, Toronto, Canada 4.15.P-Tu185

Department of Medicine, Duke University, Durham, NC 1.08.P-We172

Department of Microbiology Abia State University, PMB 2000, Uturu, Abia State, Nigeria 8.03.P-We001

Department of National Defence 2.05.P-We043

Department of Natural Resource Sciences, McGill University 1.09.T.A-06

Department of Obstetrics and Gynecology and Biomedical Research Institute, College of Medicine, Pusan National University, Pusan National University, Busan, Korea 1.08.V-01

Department of Obstetrics and Gynecology, Feinberg School of Medicine, Chicago, IL 5.04.T-01

Department of Pediatrics, Penn State University, State College, Pennsylvania, USA 5.10.P-We128

Department of Pharmaceutical Microbiology/Biotechnology, Faculty of Pharmaceutical Sciences, Abia State University, Uturu, Nigeria 5.10.P-We151

Department of Physical Sciences, MacEwan University 4.04.P-Th093, 4.04.P-Th094

Department of Renewable Resources, University of Alberta 4.14.P-We178

Department of Science and Technological Innovation, University of Eastern Piedmont "Avogadro", 15121 Alessandria 5.02.T.A-05

Department of Veterinary Medicine, Obihiro University of Agriculture and Veterinary Medicine 2.10.P-We109

Department of Wildlife Management, North Slope Borough, Barrow, Alaska 4.04.P-Th099

Department of Wildlife, Fisheries, and Aquaculture 2.07.P-We057

Dept. of Bioeng., University of California, Santa Barbara, Santa Barbara, CA, USA 4.06.P-Tu210

Dept. of Civil and Env. Eng., University of California, Davis, Davis, CA, USA. 4.06.P-Tu210

Dereviankin Consulting Inc, Alberta 4.07.T-01

DF Dickens Associates LLC 2.06.P-Th115

DHD-Consulting GmbH 3.06.T-06

Dipartimento di Chimica e Chimica Industriale, Università degli Studi di Genova, 16146 Genova, Italy 8.03.P-We003

Direction de la gestion de la faune de l'Abitibi-Témiscamingue. Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs 2.14.P-We193

Division of Analytical and Environmental Toxicology, Department of Laboratory Medicine and Pathology, Faculty of Medicine and Dentistry, University of Alberta, Edmonton, T6G 2G3, Canada. 4.08.P-We025

Division of Pulmonary, Critical Care, and Sleep Medicine, The Ohio State University, Columbus, OH 1.08.P-We172

Doctorado en Ingeniería y Ciencias Ambientales, Escuela de Post Grado, Universidad Nacional Agraria La Molina (UNALM), Lima, Perú. Facultad de Ingeniería Agrícola, Universidad Nacional del Altiplano (UNA), Puno, Perú. 5.09.V-01

Dow Chemical Company 2.02.T-06, 4.04.T.A-03, 4.18.P-Tu270, 4.22.P-Th235, 5.01.P-We062

Dow Chemical Company, Midland, MI, USA 2.02.P-Th258

Dow Inc. 4.24.T-05

Dow, Inc. 4.24.T-05

Duke Kunshan University, Division of Natural and Applied Sciences 4.24.V-01

Duke University 2.01.P-Tu080, 3.07.P-Tu054, 4.05.P-Th144, 4.06.T-05, 4.21.T-06, 6.01.P-We083

Dynanet Corporation 7.08.P-Tu136

E

EA 2.10.P-We124

EA Engineering, Science, and Technology Inc. PBC 1.06.T-01, 3.01.P-Th031, 3.02.P-We036, 3.02.T-06, 4.17.P-Tu247

EA Engineering, Science, and Technology, Inc., PBC 5.02.P-We272

East Carolina University 1.08.P-We171

Eawag 2.01.T.A-02

Eawag - Swiss Federal Institute of Aquatic Science and Technology 1.02.T-06

ECCC 4.16.T-03, 6.01.P-We082

Ecological Change and Environmental Stressors Lab, Department of Natural Resources, McGill University, Montreal, Quebec, Canada 3.08.P-Th039

Ecological Risk Inc. 3.04.P-We307

Ecology Center 4.24.P-We218

ECOMARE, CESAM—Centre for Environmental and Marine Studies, Department of Biology, University of Aveiro 2.07.P-We056

Ecostewardship LLC 5.14.T-06

EcoTox LLC 1.15.P-We198

ECOTOX- Guiney Consulting, LLC 7.12.T-01

EDF Energy 4.13.P-Th127

Egis Group 4.13.T-01

EGIS Group 2.02.T-05, 4.13.T-01

Ehime University 1.10.P-We304, 2.10.P-We120, 4.17.P-Tu234, 4.17.P-Tu235, 4.24.P-We236

Ehime University, Osaka University 1.10.P-We304

EHS Support Inc. 4.14.P-We177

EHS Support LLC 4.14.P-We177

EHSNett Consulting 4.04.T.A-03

Electron Hydro 2.01.P-Tu072

Elk Valley Resources (EVR) 1.15.P-We198, 1.15.P-We203

Enhesa 8.08.T-02

Enspired Solutions 4.08.P-We029

Env. Sci. Dept., University of California, Riverside, Riverside, CA, USA. 4.06.P-Tu210

enviPath 5.06.T-02

Enviresearch Ltd. 5.08.P-Tu129, 5.08.P-Tu132

Environment & Climate Change Canada 4.04.P-Th091, 4.04.T.A-02, 4.04.T.A-04, 4.16.T-01, 6.01.T-04

Environment Agency United Kingdom 5.01.T-04

Environment and Climate Change 5.02.P-We280

Environment and Climate Change canada 5.02.P-We280

Environment and Climate Change Canada 1.01.T-03, 1.02.P-We240, 1.02.P-We243, 1.02.P-We246, 1.05.T-01, 1.14.P-Tu227, 2.01.P-Tu069, 2.01.P-Tu071, 2.01.V-02, 2.03.P-Th013, 2.05.T-04, 2.06.P-Th113, 2.06.P-Th119, 2.06.P-Th120, 2.06.T-02, 2.06.T-05, 2.10.P-We117, 2.12.P-We185, 2.14.P-We190, 3.01.P-Th028, 3.01.T-06, 3.07.P-Tu051, 3.07.P-Tu052, 3.07.T.A-02, 3.07.T.A-03, 3.07.T.B-03, 3.07.T.B-06, 4.01.T-04, 4.04.P-Th086, 4.04.P-Th094, 4.04.P-Th096, 4.04.P-Th100, 4.04.P-Th101, 4.04.T.B-04, 4.16.T-04, 4.17.P-Tu237, 4.17.T-03, 4.18.P-Tu283, 4.22.P-Th231, 4.25.P-Th196, 5.02.P-We280, 5.02.T.B-01, 8.02.P-We257

Environment and Climate Change Canada (ECCC) 1.02.P-We240, 1.02.P-We242, 1.02.P-We243, 1.02.P-We246, 1.09.P-Tu120, 1.09.P-Tu121, 1.09.T.A-05, 1.09.T.B-01, 1.14.T-04, 1.15.T-05, 2.01.P-Tu069, 2.01.T.B-02, 2.03.T-04, 2.05.P-We040, 2.05.T-04, 2.06.P-Th118, 2.06.P-Th120, 2.07.P-We055, 2.07.T-01, 2.10.P-We117, 3.01.P-Th030, 3.01.P-Th032, 3.01.T-01, 3.01.T-02, 3.01.T-05, 3.02.T-05, 3.07.P-Tu048, 3.07.P-Tu051, 3.07.T.A-04, 3.07.T.B-02, 3.07.T.B-03, 3.07.T.B-04, 3.08.P-Th035, 3.08.P-Th036, 3.08.P-Th042, 3.08.P-Th045, 3.08.P-Th046, 4.01.P-Th162, 4.01.T-04, 4.03.P-Th164, 4.04.P-Th091, 4.04.P-Th094, 4.04.P-Th095, 4.04.P-Th097, 4.04.P-Th100, 4.04.P-Th101, 4.04.P-Th107, 4.04.T.A-04, 4.04.T.A-05, 4.04.T.B-04, 4.05.P-Th134, 4.16.T-04, 4.17.P-Tu232, 4.18.P-Tu266, 4.18.P-Tu283, 4.19.P-We210, 4.19.T-05, 4.22.P-Th231, 4.24.P-We228, 4.25.T-03, 4.26.T-02, 5.01.T-03, 5.02.P-We280, 5.02.T.B-01, 5.10.P-We148, 5.16.T-06, 7.08.P-Tu137, 8.02.T-04

Environment and Climate Change Canada (retired) 3.01.P-Th028, 3.07.T.A-02

Environment and Climate Change Canada (ECCC) 3.07.P-Tu051, 3.07.P-Tu052

Environment and Climate Change Canada, Biodiversity Research Division, Mount Pearl 1.03.P-Th019

Environment and Climate Change Canada, Canadian Wildlife Service, Dartmouth 1.03.P-Th019

Environment and Climate Change Canada, Montreal, QC, Canada 3.03.P-Tu041

Environment Canada 2.14.T-05

Environment Climate Change Canada 4.04.T.A-05

Environment Climate Change Canada (ECCC) 2.05.P-We040, 3.08.P-Th042

Environment of Climate Change Canada 1.02.P-We240

Environmental and Climate Change Canada 4.04.P-Th101

Environmental and Regulatory Resources 7.12.T-02

Environmental Control Center Co., LTD., 5.01.P-We062

Environmental Effects Research Division, Environment & Climate Change Canada 3.07.T.B-01

Environmental Geochemistry, Institute for Integrated Natural Sciences, University of Koblenz 4.10.T-06, 4.24.P-We231, 4.26.T-03

Environmental Geochemistry, Institute for Integrated Natural Sciences, University of Koblenz; Institute for Organic Biogeochemistry in Geo-Systems, RWTH Aachen University 4.10.T-06, 4.26.T-03

Environmental Health Science and Research Bureau, Healthy Environments and Consumer Safety Branch (HECSB), Health Canada, Ottawa, ON, Canada 5.10.P-We128

Environmental Health Science and Research Bureau, Healthy Environments and Consumer Safety Branch (HECSB), Health Canada, Ottawa, ON, Canada, Deparment of Epidemiology, Biostatistics and Occupational Health, McGill University, Montreal, Canada 5.10.P-We128

Environmental Health Science and Research Bureau, Healthy Environments and Consumer Safety Branch (HECSB), Health Canada, Ottawa, ON, Canada, Interdisciplinary School of Health Sciences, Faculty of Health Sciences, University of Ottawa, Ottawa, ON, Canada 5.10.P-We128

Environmental Health Science and Research Bureau, HECSB, Health Canada, Ottawa, ON 1.09.P-Tu125

Environmental Health Science and Research Bureau, HECSB, Health Canada, Ottawa, ON, Interdisciplinary School of Health Sciences, Faculty of Health Sciences, University of Ottawa, Ottawa, ON 1.09.P-Tu125

Environmental Resource Management (ERM) 4.04.T.A-03

Environmental Toxicology and Health Research Centre (TOXEN), Department of Biological Sciences, University of Quebec at Montreal, Montreal, QC, Canada 3.07.P-Tu055

Environmetrics Australia 5.16.P-We290, 5.16.P-We291

Environnement and Climate Change Canada 3.07.T.B-06

Environnements et Paléoenvironnements Océaniques et Continentaux (EPOC), CNRS, Université de Bordeaux, Bordeaux, France. 3.08.P-Th044

Envirostatus, LLC 2.06.T-04

ePrep 4.07.P-Tu139

ER2 4.24.P-We230

ERM 4.04.T.A-03

Escuela Nacional de Ciencias Biológicas, IPN 2.01.P-Tu094, 2.01.P-Tu095

ESQlabs GmbH 4.03.T-01

esqLABS GmbH, Saterland, Germany 2.01.P-Tu077

ESQlabs LLC 4.03.T-01

ESRF 3.06.P-Tu110

ETH Zurich 7.07.T-02, 7.10.P-Tu301

ETH Zürich 1.09.P-Tu124

Eurofins Agroscience Services 3.06.P-Tu112, 3.06.T-06

Eurofins Agroscience Services Ecotox GmbH 5.15.P-Tu168

Eurofins Agroscience Services Germany Holding GmbH 2.03.T-01

Eurofins Agroscience Services US 2.03.T-01, 2.03.T-02, 3.06.P-Tu113, 5.05.P-We014

Eurofins EAG Agroscience 5.01.P-We064, 5.05.P-We016

Eurofins EAG Agroscience Services 3.04.P-We310

Eurofins EAG Agroscience Services LLC US 3.04.P-We310, 3.06.P-Tu113

Eurofins EAG Agroscience Services, LLC 5.01.P-We066

Eurofins EAG Agroscience, LLC 2.02.P-Th270, 3.07.P-Tu057

Eurofins Environment Testing 4.27.T-01

Eurofins Scientific 3.04.P-We310

European Fuel Manufacturers Association Division Concawe 1.13.P-Tu039

evertéa Foundation 7.04.T-03

EVR 1.15.P-We203

EVR Operations Limited, Sparwood, BC, Canada 1.15.T-02

Exeter University 4.21.T-01

Exponent 2.13.P-Th247, 3.08.P-Th047, 4.02.T-02, 4.22.P-Th228, 4.24.P-We230

Exponent Inc. 5.10.P-We145

Exponent, Inc. 7.12.T-01

Exxon Mobil 2.06.T-04, 4.05.T-05, 5.01.P-We059, 5.02.P-We268, 5.02.T.A-01

ExxonMobil Biomedical Sciences, Inc. 1.10.T-04, 3.04.P-We305

É

École de technologie supérieure 8.04.P-Tu016, 8.09.P-Tu312

École de Technologie Supérieure 8.09.T-03

F

Facultad de Química, UAEMex 2.01.P-Tu094

Faculty of Agricultural and Environmental Sciences, McGill University, Ste-Anne-de-Bellevue 1.03.P-Th019

Faroe Marine Research Institute (FAMRI) 3.08.T-03

Federal Institute of Hydrology (BfG), Koblenz 4.09.T-05

Federal Office for the Environment (FOEN) 4.04.P-Th086

Federal University of Pernambuco 1.06.P-Th022, 1.06.T-01

Federal University of Rio de Janeiro, Institute of Chemistry, LBCD-LADETEC, Avenida Horácio Macedo, no. 1281, Polo de Química, Bloco C, Cidade Universitária, Rio de Janeiro, RJ 21941-598, Brazil 4.11.P-We162

Federal University of Rio Grande do Sul (UFRGS) 2.03.P-Th011

Field Museum of Natural History 5.07.T-04

Finnish Environment Institute 2.02.P-Th276, 2.02.P-Th277

Finnish Environment Institute (SYKE) 1.01.T-05, 2.02.P-Th276, 2.02.P-Th277

Fish & Wildlife Research Institute; Florida Fish & Wildlife Conservation Commission 2.14.P-We192

Fisheries and Oceans Canada 2.14.T-06, 3.07.P-Tu048, 3.08.P-Th041, 3.08.T-03, 4.04.P-Th100, 4.04.T.B-04, 4.17.T-03

Fisheries and Oceans Canada (DFO), Fisheries and Aquaculture Management, Vancouver, BC, Canada 3.08.P-Th039

Fisheries and Oceans Canada, Mont-Joli, QC, Canada 3.03.P-Tu041

Fisheries and Oceans Canada, Sidney, BC, Canada 3.03.P-Tu041

Fisheries and Oceans Canada, Simon Fraser University 3.08.P-Th041

Fisheries Joint Management Committee 3.07.P-Tu048

Flexsys America L.P., Akron, OH. 2.13.P-Th243

Flexsys, Akron, OH. 2.13.P-Th242

Florida Atlantic University 4.09.P-We068

Florida Atlantic University (FAU) 5.08.P-Tu129, 5.18.P-We024

Florida Fish and Wildlife Conservation Commission 2.07.T-03

Florida International University 2.10.P-We098, 3.06.V-01, 3.08.T-03, 4.06.P-Tu218, 4.12.P-Tu256, 4.18.P-Tu263, 4.21.T-02, 4.24.P-We222

Florida International University (FIU) 4.18.P-Tu263

Florida International University (FIU) Institute of Environment 2.10.P-We098, 4.18.P-Tu263, 4.19.P-We209, 4.21.T-02, 4.24.P-We222

FMC Corporation 5.02.P-We272

Fondation 2025 7.04.T-04

Former ORISE fellow at U.S. Environmental Protection Agency 8.05.P-We217

Former student at Wageningen University & Research 2.01.T.A-03

Fort Environmental Laboratories, Inc. 1.13.P-Tu034

Fountain Pen Health Communications 4.14.P-We178

FPS Health, Food Chain Safety and Environment 3.06.T-06, 5.08.P-Tu129

Fraunhofer Institute for Molecular Biology and Applied Ecology (IME) 5.08.P-Tu129

French Authority of Nuclear Safety and Radioprotection 4.13.P-Th127

French National Centre for Scientific Research (CNRS) 3.06.P-Tu108, 3.06.T-05

FTN ASSOCIATES 2.02.T-06

G

gaiac eco assessment GmbH 5.08.P-Tu133, 5.08.P-Tu134

gaiac Research Institute 5.08.P-Tu133

Galapagos Conservation Trust 2.07.T-05, 4.05.T-01

Galapagos National Park Directorate 4.05.T-01

Galveston Bay Foundation 3.07.P-Tu050

Galveston Bay Foundation, Galveston Bay Dolphin Research Program 3.07.P-Tu050

Gamberg Consulting 3.07.T.A-02, 4.04.T.A-04

GEI Consultants 1.15.P-We202

GEI Consultants, Inc. 1.15.P-We202

General Dynamics Information Technology 3.07.T.B-05, 5.06.P-We237

General Dynamics Information Technology, Inotiv 1.09.T.B-04

Genomics, Genetics and Biology Innovation Hub (Polo GGB) 5.02.T.A-05

Geomorphic Environmental Services 2.09.T-04

George Washington University 4.09.P-We078

Georgia Southern University 2.05.T-02

Georgia Southern University, Department of Biochemistry, Chemistry, and Physics 2.02.P-Th248

Georgia Southern University, Department of Biology 2.02.P-Th248

Geosyntec 2.02.T-06, 4.05.P-Th129

Geosyntec Consultants 4.02.T-04, 5.02.P-We284

Geosyntec Consultants, Inc. 1.06.P-Th022, 1.06.T-01, 3.08.P-Th034, 4.05.T-05, 5.02.P-We268, 5.02.P-We272, 5.02.P-We281, 5.02.T.A-01, 5.02.T.A-03, 5.02.T.B-02

German Environment Agency 5.14.T-01

German Environment Agency (UBA) 3.06.T-06, 5.05.P-We011, 5.14.T-01

German Environment Agency, Berlin 4.09.T-05

German Federal Institute of Hydrology (BfG) 4.22.P-Th229

GHD 5.09.P-Tu288, 5.09.P-Tu289, 5.09.P-Tu290, 5.09.P-Tu293, 5.10.P-We144, 6.01.P-We081, 7.02.T-02, 7.11.P-Tu304

Gitanyow Fisheries Authority 2.09.T-04

Glacier Bay National Park and Preserve 4.04.P-Th105

Government of Alberta 1.15.P-We206, 2.06.T-01, 2.06.T-02

Government of the Northwest Territories 4.04.P-Th105

Gradient 1.12.P-Tu225, 2.04.P-Tu101, 4.02.P-Tu198, 4.18.P-Tu265, 5.10.P-We150, 8.08.T-02

Graduate School of Pharmaceutical Sciences, The University of Osaka 4.15.P-Tu189

Grassy Narrows First Nation Mercury Justice Team 2.12.P-We184

GRAYMONT 6.03.P-Tu030

Great Lakes Environmental Center Inc. (GLEC) 2.02.P-Th273

Great Lakes Environmental Center, Inc. (GLEC) 2.02.P-Th273

Great Lakes Institute for Environmental Research (GLIER), University of Windsor, 401 Sunset Avenue, Windsor, ON N9B 3P4 4.07.T-01, 4.12.P-Tu254

Grostic Farms 8.03.P-We010

Group for Research and Education on Marine Mammals (GREMM), Tadoussac, QC, Canada 3.03.P-Tu041

GSI Environmental 1.09.P-Tu117, 3.04.P-We305, 5.02.P-We273, 5.02.P-We286

GSI Water Solutions, Inc. 5.07.T-06

Gyeongsang National University 4.05.P-Th143

GZA 5.09.P-Tu288

GZAGeoEnvironmental 5.09.P-Tu295

H

H2nanO Inc. 2.06.T-04

Haisla Nation 2.09.T-03

Hakai Institute 4.17.T-05

Haleon 2.03.P-Th012

Hamlet of Resolute Bay 4.04.T.A-05

Hanyang Univeristy 4.01.P-Th161

Hanyang University 3.07.P-Tu047, 4.01.P-Th161

Harte Research Institute 2.12.P-We187

Harvard John A. Paulson School of Engineering and Applied Sciences, Harvard University (SEAS) 4.10.T-02

Harvard T.H. Chan School of Pubic Health 4.10.T-02

Harvard T.H. Chan School of Public Health 4.10.T-02

Harvard University 4.10.P-Tu004, 4.10.T-02, 8.05.P-We216

Heal the Bay 8.05.P-We215

Health and Safety Executive (HSE) - Chemical Regulation Division 5.08.P-Tu129

Health Canada 1.09.P-Tu121, 1.09.P-Tu122, 4.03.T-03

Health Science Center, State University of Wester Parana, Cascavel, PR, Brazil 2.06.T-03

Heiltsuk Integrated Resource Management Department, Bella Bella, BC 2.07.P-We058

Heiltsuk Integrated Resource Management Department, Bella Bella, BC, Canada, AND State University of New York College of Environmental Science and Forestry, Department of Environmental Biology, Syracuse, NY, United States 2.07.P-We058

Helmholtz Centre for Environmental Research (UFZ) 1.09.P-Tu126, 4.22.P-Th229

Heriot Watt University 2.01.T.B-03, 3.07.T.A-06

Heriot-Watt University 3.07.T.A-06

HESI Global 1.09.T.A-01, 1.10.T-03, 1.13.T-02, 5.01.P-We059, 5.01.P-We060, 5.01.T-03, 5.01.T-04

High Arctic Institute 4.04.P-Th090, 4.04.P-Th098, 4.04.T.B-01

Higher Polytechnic School of the Coast (ESPOL) 2.07.T-05

Hochschule für Technik und Wirtschaft Dresden - University of Applied Sciences 2.13.T-06

Hokkaido University 3.08.P-Th043

Hôpital pour Oiseaux et Animaux Exotiques de Montréal, Montreal 1.03.P-Th019

Household Consumer Products Association 8.08.T-02

HUGIN EXPERT 2.01.P-Tu078, 4.23.T-02

Huntsman Marine Science Center 1.03.T-04, 2.13.P-Th241

Huntsman Marine Science Centre 2.07.P-We046

Huntsman Marine Science Centre, St. Andrews, NB 2.07.P-We058

HX Expeditions 4.16.V-01

Hydro-Québec Environnement 4.26.T-05

Hyla Environmental Consulting LLC 4.04.T.A-03

I

ibacon GmbH 5.08.P-Tu129

Ibacon GmbH 5.15.P-Tu168

Idaho Department of Environmental Quality 2.05.T-03

Idaho Department of Fish and Game 4.23.T-05

Ifremer 1.07.P-We097

IFSP _Sertãozinho 2.10.P-We113

IISD Experimental Lakes Area 2.06.P-Th115

IISD Experimental Lakes Area (IISD-ELA) 2.09.P-Tu033, 6.03.P-Tu024

IISD-ELA 2.01.P-Tu071

IISD-Experimental Lakes Area 5.04.T-04

Imo State University 6.05.P-Th199

Imperial College London 4.05.T-01

independent 4.11.P-We164

Independent Research 4.18.V-02

Indian Institute of Technology Delhi 8.03.P-We004

Indiana University Bloomington 4.06.T-06, 5.16.T-05

Industrial Economics Inc. (IEc) 6.01.P-We080

Industrial Economics, Inc. (IEc) 6.01.P-We080

Inotiv 1.09.T.B-04

INRAE 2.07.T-02

INRAE – Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement, UR RiverLy, Ecotox Team, 69100 Villeurbanne, France. 2.01.P-Tu068

INRS 2.09.T-02, 2.14.P-We195, 2.14.P-We196, 4.02.P-Tu193, 4.04.T.B-06

INRS Eau Terre Environnement 2.06.P-Th116

INRS, Centre Armand-Frappier Santé Biotechnologie, Laval, QC 1.09.P-Tu125

Institue of Biochemistry and BioPhysics Polish Academy of Sciences 4.04.T.A-03

Institut de pharmacologie de Sherbrooke, Université de Sherbrooke, Sherbrooke, Canada 3.03.P-Tu041

Institut des sciences de l'environnement, Département des Sciences Biologiques, TOXEN – EcotoQ, Ecotoxicology of Aquatic Microorganisms Laboratory, Université du Québec à Montréal, Succursale Centre-ville, C.P. 8888 Montréal, Québec, H3C 3P8, Canada 2.01.P-Tu093

Institut des sciences de la mer 2.05.T-05

Institut des sciences de la mer de Rimouski, Université du Québec à Rimouski 2.01.P-Tu081

Institut des Sciences de la Mer, Université du Québec à Rimouski (ISMER-UQAR) 4.04.T.A-01

Institut national de la recherche scientifique 1.05.P-Th185, 2.09.T-01, 2.14.P-We194, 4.04.P-Th089, 4.18.P-Tu280, 4.23.P-Tu155

Institut National de la Recherche Scientifique 2.07.P-We049, 2.10.P-We116, 2.14.T-04, 4.04.T.B-02

Institut National de la Recherche Scientifique (INRS) 4.04.P-Th088, 4.04.T.A-01, 4.14.P-We176

Institut National de la Recherche Scientifique, Centre Eau Terre Environnement 1.13.P-Tu038

Institut national de la recherche scientifique, Centre Eau Terre Environnement, Québec (QC), Canada 4.19.T-01

Institut national de la recherche scientifique, Centre Eau Terre Environnement, Quebec, Canada 7.04.T-03

Institut Químic de Sarrià-Universitat Ramon Llull 1.04.P-Th167

Institute for Advanced Medical Research and Training (IAMRAT), College of Medicine, UCH, Ibadan 5.10.P-We132

Institute for Frontier Materials, Deakin University, Melbourne 1.12.P-Tu226

Institute for Interdisciplinary Mountain Research 4.04.P-Th091, 4.04.T.A-04

Institute for Marine and Antarctic Studies, University of Tasmania 3.03.P-Tu042

Institute for Organic Biogeochemistry in Geo-Systems, RWTH Aachen University 4.10.T-06, 4.26.T-03

Institute of Biochemistry and Biophysics Polish Academy of Sciences 4.04.T.A-03

Institute of Energy and the Environment, The Pennsylvania State University, University Park, Pennsylvania 4.06.P-Tu215

Institute of Environmental Assessment and Water Research 1.13.P-Tu038

Institute of Environmental Assessment and Water Research - Spanish National Research Council (IDAEA-CSIC) 1.04.P-Th166, 1.04.P-Th167, 1.13.P-Tu038

Institute of Environmental Assessment and Water Research (IDAEA-CSIC) 1.04.P-Th167

Institute of Environmental Assessment and Water Research (IDAEA-CSIC), Barcelona, Spain 1.04.P-Th166

Institute of Environmental Medicine, Karolinska Institute 4.19.P-We208

Institute of Feed Research, Chinese Academy of Agricultural Sciences, Beijing, China, Beijing, China. 3.04.V-01

Institute of Marine Sciences (ICM-CSIC) 1.04.P-Th167

Institute of Nanostructured Materials (ISMN), National Research Council (CNR), 40129 Bologna, Italy 8.03.P-We003

Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, British Columbia 4.17.P-Tu250

Institute of Science, Technology and Sustainability or Ceramics (ISSMC), National Research Council (CNR), 48018 Faenza (RA), Italy 8.03.P-We003

Instituto BW 3.07.T.A-05

Instituto de Ceramica y Vidrio 8.03.T-02

Instituto de Cerámica y Vidrio 8.03.T-02

Instituto Federal de São Paulo - IFSP - Campus Sertãozinho 2.01.P-Tu086

Instituto Nacional del Agua 4.11.P-We161

INTA 3.01.P-Th029, 4.11.P-We161

Integral Consulting Inc. 5.14.T-02

Interdisciplinary Arts and Sciences, University of Washington Tacoma, Tacoma, WA 98402 ; Center for Urban Waters, Tacoma, WA 98421, USA 4.09.P-We076

Interdisciplinary Research Laboratory on Sustainable Engineering and Ecodesign (LIRIDE), Department of Civil and Building Engineering, Université de Sherbrooke, Sherbrooke, Canada 8.04.P-Tu017

Interdisciplinary School of Health Sciences, Faculty of Health Sciences, University of Ottawa, Ottawa, ON 1.09.P-Tu125

Interdisciplinary Science and Engineering Laboratory, Department of Plant and Soil Sciences, University of Delaware, Newark, DE 19716, USA 8.03.P-We003

International Collaboration on Cosmetics Safety 5.09.T-02

International Collaboration on Cosmetics Safety (ICCS) 1.09.T.B-02, 5.09.T-02

INTERNATIONAL COPPER ASSOCIATION 1.01.P-Tu010

International Copper Association (ICA) 1.13.T-05

International Crane Foundation 3.07.T.B-01

International Institute for Sustainable Development – Experimental Lakes Area 2.08.P-Tu059, 2.08.P-Tu060

International Institute for Sustainable Development (IISD) 2.02.P-Th252, 2.08.P-Tu061, 4.09.P-We070, 5.04.P-We251, 5.04.P-We253, 5.04.T-06

International Pacific Halibut Commission 4.04.P-Th092

International Zinc Association (IZA) 1.01.T-02

Iowa State University 4.22.T-01, 4.27.T-04, 5.02.P-We285

IRBV, Universite de Montreal 6.03.P-Tu025

J

Jacksonville University 2.07.P-We051

Jacobs 2.02.T-06, 5.02.T.B-06

Jacobs Engineering Group Inc 5.02.P-We272, 5.02.P-We283

Jai Research Foundation (JRF) 4.02.P-Tu194

James Madison University 4.06.P-Tu218

Jefferson Lab, Department of Energy 4.06.P-Tu218

John L Holmes Mass Spectrometry Facility, University of Ottawa, Ottawa, ON 1.09.P-Tu125

Jordan Valley Innovation Center 6.01.T-03

K

Kagoshima university 3.07.P-Tu058

Kagoshima University 1.05.P-Th184, 2.02.P-Th271, 2.07.P-We054, 3.07.P-Tu058, 4.09.P-We071, 4.17.P-Tu234, 4.17.P-Tu235, 4.24.P-We236

Kanesatake Ratishontsanonhstats Environment 5.07.P-We165

Kao Corporation 1.09.T.B-02, 2.07.P-We052, 5.09.T-02

Karolinksa Institutet (KI) 4.19.P-We208

Key Laboratory of Coastal Environment and Resources of Zhejiang Province, School of Engineering, Westlake University, Hangzhou 310030, China 5.09.V-01

Key Laboratory of Coastal Environment and Resources of Zhejiang Province, School of Engineering, Westlake University, Hangzhou, Zhejiang, China; College of Environmental and Resource Sciences, Zhejiang University, Hangzhou, Zhejiang, China. 5.09.V-01

Key Laboratory of Water and Air Pollution Control of Guangdong Province, South China Institute of Environmental Sciences, MEE, Guangzhou 510655 4.15.P-Tu182

Kilgour & Associates Ltd. 1.01.T-03

Knox College 2.08.P-Tu064, 2.08.P-Tu065, 2.08.P-Tu066

Kootenai Tribe of Idaho 1.15.P-We205

Korea Research Institute of Chemical Technology (KRICT) 5.06.P-We239

Korea Research Institute of Ships and Ocean Engineering 4.01.P-Th161

Korea University 8.06.P-Th186

Kyung Hee University 4.15.P-Tu186, 4.18.P-Tu282

Kyushu University 2.10.P-We118

Kyushu University, Fukuoka, Japan 2.10.P-We118

L

L.S. McCarty Scientific Research & Consulting 2.01.T.A-01

L'Oreal 1.09.T.B-02, 5.09.T-02

Laberca 2.07.T-02

Laboratoire Chrono-environnement, CNRS, Université de Bourgogne Franche-Comté, Besançon, France. 3.08.P-Th044

Laboratorio Nacional de Resiliencia Costera (LANRESC) 7.05.P-We157

Laboratory of Evolutionary and Adaptive Physiology, Department of Biology, Université de Namur, Namur, Belgium 3.03.P-Tu041

Laboratory of Food Systems Analytics, Department of Data Science, School of Data Science, Pusan National University, Busan, Korea 1.08.V-01, 1.08.V-02

Laboratory of Toxicology, Department of Environmental Veterinary Sciences, Faculty of Veterinary Medicine, Hokkaido University, Kita 18 Nishi 9, Kita-ku, Sapporo 060-0818 4.23.P-Tu160

Laboratory of Toxicology, Department of Environmental Veterinary Sciences, Faculty of Veterinary Medicine, Hokkaido University, Kita 18 Nishi 9, Kita-ku, Sapporo 060-0818 Japan 4.23.P-Tu160

Lake Winnipeg Foundation 2.08.P-Tu059

Lakeland University 1.06.P-Th024, 1.06.P-Th027

Landesanstalt für Umwelt Baden-Württemberg, Karlsruhe 4.09.T-05

Laval University 1.07.P-We097, 3.08.T-01, 4.04.P-Th102, 4.24.P-We224

Lead City University 5.10.P-We131, 5.10.P-We132

LeTourneau University 7.08.P-Tu138

LGC Standards 4.02.P-Tu204

LIRIDE - Sherbrooke University 8.04.P-Tu019

Louis Malardé Institute 1.07.P-We097

Louisiana State University 1.03.T-01, 1.03.T-04, 1.03.T-06, 1.09.P-Tu119, 1.13.T-06

Louisiana State University Baton Rouge 1.03.T-01, 1.03.T-04, 1.03.T-05, 1.03.T-06, 1.09.P-Tu119, 1.13.T-06

Lund University 5.16.P-We297

Luossavaara-Kiirunavaara AB (LKAB) 1.01.T-05, 2.02.P-Th276, 2.02.P-Th277

LUT University 8.01.T-03

M

Machine Learning Engineer 7.05.P-We160

Maclean Environmental Consulting 2.06.T-02

Maine Department of Environmental Protection 2.10.P-We100

Makate Waagamichiwanang Gakinaa'amaatiwin Youth and Family Wellness Camp 6.03.P-Tu024

Manipal Institute of Applied Physics, Manipal Academy of Higher Education, Manipal - 576104, Karnataka, India 4.24.P-We221

Mannaki-Whenua Landcare Research 5.07.T-02

Marine Academy of Technology and Environmental Science, Stafford Township, NJ 3.02.T-06

Markes International Ltd 4.15.P-Tu182

Markes International, Inc., Sacramento, California 95670 4.15.P-Tu182

Markes International, Shanghai 201109 4.15.P-Tu182

Maryland Department of Natural Resources, Wye Mills, MD 3.02.T-06

Masaryk University 4.16.V-01

MASc Student 8.02.T-01

Mcgill University 1.05.P-Th180

McGill University 1.03.T-04, 1.05.P-Th180, 1.05.P-Th183, 1.05.T-04, 1.05.T-05, 1.05.T-06, 1.08.P-We168, 1.09.P-Tu120, 1.09.P-Tu123, 1.09.T.A-05, 1.09.T.B-03, 1.14.T-02, 1.14.T-06, 2.01.T.B-02, 2.02.P-Th257, 2.03.P-Th007, 3.01.P-Th030, 3.01.T-01, 3.01.T-04, 3.01.T-05, 3.01.T-06, 3.07.T.B-04, 3.08.P-Th036, 3.08.P-Th042, 3.08.P-Th045, 3.08.T-03, 3.08.T-05, 4.01.P-Th158, 4.01.T-03, 4.03.P-Th164, 4.04.T.B-04, 4.04.T.B-05, 4.05.P-Th137, 4.05.T-03, 4.07.T-04, 4.15.P-Tu172, 4.15.P-Tu173, 4.15.T-01, 4.17.P-Tu240, 4.22.P-Th221, 4.22.P-Th229, 4.23.P-Tu152, 4.23.P-Tu159, 4.24.P-We219, 4.24.P-We221, 4.24.T-06, 4.25.P-Th195, 5.04.P-

We249, 5.07.T-03, 7.07.T-01, 7.08.P-Tu137, 8.01.T-06, 8.02.T-04, 8.02.T-06, 8.03.P-We007, 8.03.T-01, 8.03.T-05, 8.08.P-Tu309, 8.08.T-02, 8.09.P-Tu311, 8.09.P-Tu313, 8.09.P-Tu314, 8.09.T-02, 8.09.T-06

McGIll University 8.01.T-06

McGill University; Dalhousie Univerisity 3.01.T-04

McGill University's Center for Indigenous Peoples' Nutrition and Environment (CINE) 5.07.P-We165

McMaster University 1.02.P-We242, 1.04.P-Th170, 1.06.T-06, 1.07.P-We094, 1.09.P-Tu116, 2.02.P-Th252, 2.02.P-Th263, 2.03.T-04, 2.10.P-We102, 3.01.P-Th028, 3.01.T-02, 3.01.T-05, 3.01.T-06, 3.07.T.A-02, 3.08.P-Th042, 3.08.P-Th045, 4.01.P-Th157, 4.01.P-Th335, 4.01.T-06, 4.05.P-Th149, 4.06.P-Tu212, 4.06.T-02, 4.22.P-Th219, 4.22.T-06, 5.02.T.B-01, 5.04.P-We251, 5.04.P-We252, 5.04.P-We253, 5.04.T-04, 5.04.T-06, 5.09.T-03

McMaster University, Nautilus Environmental 1.07.P-We094, 1.09.P-Tu116

Meharry Medical College 4.22.P-Th224

Memorial University of Newfoundland 1.04.P-Th173, 2.03.P-Th005, 4.01.T-03

Mérieux NutriSciences 2.09.T-03

MERINOV, Centre d'Innovation de l'aquaculture et des Pêches du Québec 2.01.P-Tu081

Metro Vancouver 2.02.P-Th265

Metrology Research Centre, National Research Council (NRC) Canada 4.15.P-Tu190

Metrology Research Centre, National Research Council Canada 4.15.P-Tu190

Metropolitan Autonomous University 4.18.P-Tu269

Metropolitan Autonomous University (UAM) 4.18.P-Tu269

Metropolitan Water District of Southern California (MWD) 2.10.P-We121, 5.16.P-We296, 7.10.P-Tu299

Metropolitan Water Reclamation District of Greater Chicago 1.06.P-Th024

Mi'gmaq Wolastoqey Indigenous Fisheries Management Association 2.01.P-Tu081

Michael Okpara University of Agriculture Umudike 6.05.P-Th203

Michigan Department of Health and Human Services 1.01.P-Tu014, 7.05.P-We154

Michigan Department of Natural Resources 7.04.T-02

Michigan State University 1.06.P-Th024, 1.06.P-Th027, 1.06.T-02, 1.06.T-03, 3.02.P-We033, 5.08.P-Tu131, 7.04.T-02, 8.03.P-We010

Middle Tennessee State University 2.02.P-Th266

Ministère de l'Environnement et de la Lutte contre les changements climatiques, Ville de Québec, Canada 8.04.P-Tu017

Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs 1.01.T-01, 8.02.P-We257

Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs (MELCCFP) 5.17.P-We259

Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs, Québec 6.01.T-01

Ministry of Environment Conservation and Parks, Toronto, Ontario, M7A 2E3 4.07.T-01

Ministry of Environment Quebec 1.01.T-03, 1.05.T-06

Ministry of the Environment, Conservation and Parks 4.01.T-04, 4.19.P-We210

Ministry of the Environment, the Fight against Climate Change, Wildlife and Parks (MELCCFP) 1.05.T-06, 4.01.P-Th162, 4.17.P-Tu240

Missouri Cooperative Fish and Wildlife Research Unit, University of Missouri 2.02.P-Th274

Missouri State University 5.02.P-We274

Montana Fish, Wildlife & Parks 1.15.T-03

Montana State University 4.08.P-We029

Montreal University Health Centre (CHUM) 3.06.T-04

Montrose 4.02.T-06

Moore Institute for Plastic Pollution Research 4.17.T-01

Mosaic Biosciences 5.05.P-We012

Mount Desert Island Biological Laboratory 4.02.T-01

MTU 4.24.P-We229

Multiuser Laboratory of Molecular Characterization and Mass Spectrometry, Institute of Exact and Biological Sciences, Federal University of Ouro Preto, Ouro Preto, Minas Gerais, Brazil 4.11.P-We162

Murray State University 5.09.P-Tu291

N

N/A 4.05.P-Th129

Nankai University 4.07.T-05, 4.09.P-We067

Nantes Université, Institut des Substances et Organismes de la Mer, ISOMer, UR 2160, F-44000 Nantes 2.07.P-We056

Nantes Université, Laboratoire de Planétologie et Géosciences, LPG, UMR CNRS 6112, F-44000 Nantes 2.07.P-We056

National Autonomous University of Mexico 2.02.P-Th259

National Autonomous University of Mexico (UNAM) 2.02.P-Th259, 4.18.P-Tu269, 5.09.P-Tu298, 7.05.P-

We157

National Center for Energy and Environment, University of Benin, Benin-City, 2.02.V-01

National Center For Energy and Environment. 4.23.V-01

National Centers for Coastal Ocean Science (NCCOS) 3.06.P-Tu103, 4.07.P-Tu144, 5.02.T.A-02, 6.01.T-05, 6.02.P-Th110, 7.02.T-03

National Institute for Environmental Research (NIER) 2.03.P-Th006

National Institute for Environmental Studies 4.24.P-We236

National Institute for Environmental Studies (NIES) 1.09.P-Tu126, 2.03.P-Th006, 4.02.P-Tu203, 4.09.P-We071, 4.22.P-Th226, 5.04.P-We247

National Institute for Environmental Stuides (NIES) 5.04.P-We247

National Institute for Scientific Research (INRS) 1.01.T-03, 1.13.P-Tu038, 2.01.P-Tu083, 2.02.P-Th253, 2.04.P-Tu102, 2.04.T-04, 2.04.T-06, 2.06.P-Th117, 2.07.P-We049, 2.07.P-We053, 2.09.T-05, 2.09.T-06, 2.10.P-We115, 2.10.P-We116, 2.14.T-01, 3.07.T.A-04, 3.07.T.B-04, 4.01.P-Th158, 4.04.T.B-02, 4.13.P-Th122, 4.13.P-Th124, 4.14.P-We179, 4.18.P-Tu279, 4.18.P-Tu280, 7.04.T-01, 8.02.T-03

National Institute for Scientific Research (INRS) Canada 2.01.P-Tu083

National Institute for Scientific Research (INRS) 8.04.P-Tu018

National Institute of Advanced Industrial Science and Technology 4.24.P-We236, 5.01.P-We062, 5.10.P-We146

National Institute of Advanced Industrial Science and Technology (AIST) 2.03.P-Th016, 4.24.P-We223

National Institute of Health Sciences 4.18.P-Tu268

National Institute of Health Sciences (NIHS) 4.18.P-Tu268

National Institute of Public Health 5.16.T-01

National Institute of Standards and Technology (NIST) 4.15.T-02, 4.18.P-Tu278

National Oceanic and Atmospheric Administration 7.10.P-Tu300, 7.10.P-Tu302

National Oceanic and Atmospheric Administration (NOAA) 2.10.P-We119, 3.06.P-Tu103, 4.04.P-Th099, 4.07.P-Tu144, 4.23.P-Tu156, 5.02.P-We276, 5.02.P-We277, 5.02.T.A-02, 6.01.T-05, 6.01.T-06, 6.02.P-Th109, 6.02.P-Th110, 7.02.T-03, 7.10.P-Tu302

National Oceanic and Atmospheric Administration (NOAA) 3.06.P-Tu103, 5.02.T.A-02

National Park Service 4.15.P-Tu188

National Research Council (NRC) Canada 4.26.T-06

National research Council Canada 4.26.T-06

National Research Council Canada 4.04.P-Th104, 4.26.T-06, 8.09.T-05

National University of Distance Education (UNED) 2.01.P-Tu074, 2.02.P-Th249

National University of Tainan 2.01.P-Tu077

Natural History Museum and Institute 3.08.P-Th043

Natural History Museum of Los Angeles County 8.05.P-We215

Natural Resources Canada 1.01.T-03, 2.06.P-Th116, 2.06.P-Th117, 2.07.P-We049, 2.12.P-We183

Natural Resources Canada-CanmetENERGY Devon 4.18.P-Tu274

Natural Resources Research Institute (NRRI) 2.13.P-Th244, 4.17.T-02

Nature Saskatchewan 3.07.T.B-01

Nautilus Environmental Company 2.03.T-04, 2.07.T-01

Nautilus Environmental Company Inc. 2.07.T-01

Nautilus Environmental, Inc. 3.03.P-Tu043

Naval Facilities Engineering Systems Command, Northwest (NAVFAC NW) 4.02.P-Tu208

Naval Information Warfare Center Pacific 4.05.P-Th139, 5.02.T.B-02, 6.03.P-Tu027, 6.03.P-Tu028

Naval Information Warfare Center Pacific (NIWC Pacific) 4.05.T-05, 5.02.P-We284, 5.02.T.A-01, 5.02.T.A-03, 5.02.T.B-02, 6.03.P-Tu027, 6.03.P-Tu028

NC State University 5.05.P-We012

NC3Rs 1.13.T-02

New Brunswick Museum 3.02.P-We035

New York State Department of Environmental Conservation’s Bureau of Habitat 4.23.P-Tu150

New York State Water Resources Institute at Cornell University 4.23.P-Tu150

New Zealand Environmental Protection Authority 7.07.T-03

NewRange Copper Nickel 1.15.P-We206

NIH/NIEHS/DTT 1.09.T.B-04

NIH/NIEHS/DTT/NICEATM 7.08.P-Tu136

NILU 4.04.T.A-03

NILU / University of Oslo Norway 4.04.P-Th086

Nippon Veterinary and Life Science University 4.24.P-We236

NIVA 4.16.V-01

NIWC Pacific 5.02.T.B-02

No Affiliation 1.06.P-Th027, 1.09.T.B-03, 2.01.V-02, 2.02.P-Th266, 2.06.T-04, 2.07.P-We057, 2.07.T-02,

2.13.T-04, 3.07.P-Tu048, 4.04.T.A-05, 4.04.T.B-04, 4.06.T-03, 4.12.P-Tu253, 4.23.T-04, 4.25.T-03, 5.10.P-We145, 5.16.P-We296, 5.16.P-We298, 7.02.T-03, 7.03.T-05, 8.08.T-02

NOAA 4.17.P-Tu246, 4.18.P-Tu273, 6.02.P-Th111

Noack Laboratorien 3.06.T-06

Noblis 7.05.P-We159, 7.05.P-We160

North Carolina Department of Environmental Quality (DEQ) 5.02.T.A-04

North Carolina State University 1.08.P-We173

North Carolina Wildlife Resources Commission (WRC) 5.02.T.A-04

North Hill Group 5.05.P-We012

Northeastern University 4.17.P-Tu244

Northern Alberta Institute of Technology 2.06.T-04

Northern Kentucky University (NKU)-Waters Lab 5.10.P-We152

Norwegian Geotechnical Institute (NGI) 5.16.P-We290, 5.16.P-We291

Norwegian Institue for Water Research (NIVA) 4.23.T-02

Norwegian Institute for Air Research 4.04.P-Th106

Norwegian Institute for Air Research (NILU) 4.04.T.A-03

Norwegian Institute for Water Research (NIVA) 2.01.P-Tu078, 4.23.T-02, 4.24.P-We227, 5.16.P-We290, 5.16.P-We291

Norwegian Institute of Water Research 4.17.T-01

Norwegian University of Science and technology (NTNU) 8.01.T-02

Norwegian University of Science and Technology (NTNU) 3.08.P-Th046, 4.17.P-Tu231, 8.01.T-02

Nova Southeastern University 2.03.P-Th002, 2.03.T-06

Novamechanics Ltd 5.02.T.A-05

Novonesis 5.05.P-We012

Nunavik Research Centre 3.08.T-01

Nunavut Environment Department 4.04.P-Th101

O

Oak Ridge Institute for Science and Education 1.13.P-Tu034

Oak Ridge Institute for Science and Education (ORISE) 1.03.P-Th020, 1.05.P-Th181, 1.05.T-02, 1.05.T-03, 1.06.P-Th026, 3.07.T.B-05, 4.19.P-We207, 5.01.T-02

Oak Ridge Institute for Science and Education (ORISE) research participant at US EPA 1.05.P-Th182

Oak Ridge Institute for Science and Education (ORISE) 1.13.T-01

Oak Ridge National Lab 1.06.T-02

Oak Ridge National Laboratory 1.06.P-Th024, 1.06.P-Th027, 1.06.T-03, 5.08.P-Tu131

Ocean University of China 4.01.P-Th156

Ocean Wise Conservation Association 4.26.T-04

Office of the Assistant Secretary of War (Energy, Installations, & Environment) 7.05.P-We159

Ohio State University 3.04.P-We306, 6.03.P-Tu022

Okinawa Prefectural Institute of Health and Environment 4.02.P-Tu203

Oklahoma State University 4.10.P-Tu003

Old Dominion University 3.04.P-We305, 4.27.T-02

One Health Research Center, Hokkaido University, Sapporo 060-0818 4.23.P-Tu160

Ontario Ministry of the Environment, Conservation and Parks 4.05.P-Th131, 4.22.T-02

Ontario Tech University 1.02.T-01, 1.09.P-Tu128, 4.03.P-Th165, 4.12.P-Tu258, 4.13.P-Th125, 5.02.P-We282, 5.04.P-We251, 5.04.T-06, 5.17.P-We264, 5.17.P-We265, 5.17.P-We266, 5.17.P-We267

OntarioTech University 2.10.P-We106

OntarioTechUniversity 2.10.P-We106

Oregon Department of Environmental Quality 5.07.T-06

Oregon Department of Environmental Quality (DEQ) 5.07.T-06

Oregon State Univeristy 1.12.P-Tu221

Oregon State University 1.08.P-We170, 1.08.P-We171, 1.12.P-Tu221, 4.05.P-Th135, 4.05.P-Th141, 4.05.P-Th142, 4.10.T-03, 4.24.P-We235, 4.27.T-05, 5.01.T-05, 5.02.P-We281, 5.10.P-We134, 7.03.T-01

Oregon State University Department of Environmental and Molecular Toxicology 4.05.P-Th145, 4.05.P-Th146

Oregonians for Food & Shelter 7.03.T-01

Organisation for Economic Co-operation and Development (OECD) 4.04.P-Th086

ORISE at US EPA 1.06.T-05

ORISE fellow at U.S. Environmental Protection Agency 8.05.P-We217

ORISE U.S. EPA 1.05.T-02, 4.19.P-We207

Osaka Metropolitan University 4.02.P-Tu203

Osnabrück University 5.15.P-Tu166

Owens Coastal Consultants 2.06.P-Th115

P

Pace Labs 4.02.P-Tu204

Pacific Northwest National Laboratory 4.05.P-Th146, 4.10.T-03

Pacific Northwest National Laboratory (PNNL) 4.10.T-03

Palustris Environmental 2.06.P-Th118

Parks Canada Agency 2.06.T-02

Pegasus Technical Services, Inc. 8.05.P-We217

Peking University 7.10.P-Tu301

Peninsula Streams and Shorelines 2.13.P-Th239

Personal Care Products Council (PCPC) 5.14.T-06

Pest Management Regulatory Agency, Health Canada, Government of Canada 4.23.P-Tu153

Pesticides Regulatory Directorate, Healthy Environments and Consumer Safety Branch, Health Canada 4.23.T-06

PETA Science Consortium International e.V. 1.09.P-Tu124, 1.09.T.B-02, 5.09.T-02, 7.03.T-06

Peterson Global Agriculture Development 5.05.P-We012

Phd Student 5.16.P-We292

PhD Student 4.15.T-06

Phenomenex 4.02.P-Tu200, 4.25.T-01

Pinchin Ltd. 5.10.P-We142, 5.10.P-We143

Polar Knowledge Canada, Government of Canada, Cambridge Bay, Nunavut, Canada 4.04.P-Th103

Polytech Marseille, Aix-Marseille University 1.13.P-Tu037

Post Graduate Program in Environmental Engineering, Federal University of Ouro Preto, 35400-000, Ouro Preto, Minas Gerais, Brazil 4.11.P-We162

Post Graduate Program in Environmental Engineering, Federal University of Ouro Preto, 35400-000, Ouro Preto, Minas Gerais, Brazil. 4.11.P-We162

Postdoctoral Researcher 4.15.T-06

Potomac River Keeper Network 7.02.P-Th207

Principle Investigator 8.02.T-01

Procter & Gamble 1.09.T.B-02

Production Technology & Diversified Cropping Systems Group, Department of Plant Production, AgroScope, Nyon, Switzerland & Academy of Global Food Economics and Policy, China Agricultural University, China 5.09.V-01

Professor 4.15.T-06

Public Health Agency of Canada 8.02.T-02

Public Health Agency of Canada (PHAC) 8.02.T-06

Public Health Ontario 8.02.T-05

Public Services and Procurement Canada 2.05.P-We043

Pukyong National University 1.07.P-We096

Purdue University 8.03.T-06

Q

QIAGEN 8.08.P-Tu309

Québec’s National Public Health Institute (INSPQ) 4.21.P-Th154

Queen's University 2.01.T.B-02, 2.06.T-05, 3.02.T-05, 3.06.T-02, 3.06.T-03, 4.04.P-Th107, 4.07.T-06, 4.16.T-04, 4.17.P-Tu250, 8.02.P-We256, 8.02.T-01, 8.02.T-05

Queens University 4.04.T.A-05, 6.01.P-We082

Queensland Alliance for Environmental Health Sciences, University of Queensland 3.03.P-Tu042

Quesnel River Research Centre, University of Northern British Columbia 6.01.P-We082

R

Raincoast Conservation Foundation 2.07.P-We050, 2.13.P-Th238, 5.07.T-05

Ramboll 2.07.T-06, 3.08.P-Th033, 5.10.P-We130

Ramboll Americas Engineering Solutions, Inc. 1.07.P-We095

Ramboll Deutschland GmbH 1.07.P-We095

Ramo Inc. 6.03.P-Tu025

Ramon Llull University 1.04.P-Th167

Ratihén:te High School, Kanehsatà:ke Education Center 5.07.T-03

Ratishontsanonhstats Kanesatake Environment, Mohawk Council of Kanesatake 5.07.T-03

RCH Resource Management 4.14.P-We178

RECETOX Switzerland 4.04.P-Th086

Red Cap Consulting 1.15.T-01

Redeemer's University, Ede, Osun State 5.10.P-We132

Region of Waterloo 4.22.P-Th215

Regional Centre for Biotechnology and Bioresources Research, University of Port Harcourt, East-West Road, Choba, Port Harcourt, Rivers State 6.05.V-02, 6.05.V-03

Regulatory Toxicology Research Division, Health Product and Food Branch, Health Canada, Ottawa, ON 1.09.P-Tu125

Research and Innovation Centre. Edmund Mach Foundation, San Michele all'Adige 4.23.P-Tu149

Research Center for Industries of the Future, Westlake University, Hangzhou 310030, China; Key Laboratory of Coastal Environment and Resources of Zhejiang Province, School of Engineering, Westlake University, Hangzhou 310030, China; Institute of Advanced Technology, Westlake Institute for Advanced Study, Hangzhou 310030, China 5.09.V-01

Research Institute of Environment, Agriculture and Fisheries, Osaka Prefecture 4.02.P-Tu203, 4.22.P-Th226

Research Planning Inc (RPI) 7.02.T-03

Research Scientist, Environmental Health Science and Research Bureau, Health Canada, Ottawa, Ontario, Canada; Professor, Department of Biology, University of Ottawa, Ottawa, Ontario, Canada 1.07.P-We091

Research Unit in Environmental and Evolutionary Biology, Department of Biology, Université de Namur, Namur, Belgium 3.03.P-Tu041

Réseau Environnement 7.04.T-04

Resolute Bay 4.04.P-Th091, 4.04.T.A-04, 4.24.P-We228

Retired 4.13.P-Th127

Rhenus Lub GmbH & Co KG 2.06.P-Th121

Rhineland-Palatinate Technical University Kaiserslautern-Landau (RPTU) 2.01.P-Tu089, 2.01.P-Tu090, 4.23.P-Tu149

Ricardo-AEA Ltd 4.24.P-We230

Ricardo-AEA Ltd. 4.24.P-We230

RIFCON GmbH 5.08.P-Tu129

Rio Tinto 4.14.P-We177, 8.06.P-Th187

Rise Over Run Environmental 5.16.P-We299

Rise Over Run Environmental, BQE Water. Previously Nautilus Environmental 2.02.P-Th269

RJ Lee Group 4.27.T-03

RJ Lee Group, Inc. 4.27.T-03

Rowan University 2.07.P-We047

Royal Military College 3.06.T-02, 3.06.T-03

Royal Roads University 4.07.P-Tu143

RPTU University Kaiserslautern-Landau 7.03.P-We084

Ruder Boskovic Institute 5.18.P-We024

S

Safer Chemistry Advisory 8.08.P-Tu308

Saga Prefectural Genkai Fisheries Research and Development Center, Karatsu, Saga, Japan 2.10.P-We118

Saint Mary's University 2.01.T-05, 2.02.P-Th260, 2.02.P-Th268, 3.02.P-We035, 6.03.P-Tu023

Saint Mary's University & EGCB Canada 4.13.T-06

San Diego State University Research Foundation 4.05.P-Th139

San Francisco Estuary Institute 2.13.T-04, 3.07.P-Tu045, 4.10.P-Tu004, 4.15.P-Tu177, 4.17.T-01, 4.21.P-Th147, 4.21.T-06, 4.24.P-We227, 5.04.T-03, 5.04.T-05

San Francisco Estuary Institute (SFEI) 4.24.P-We227

Sanexen Environmental Services Inc. 5.10.P-We147

São Paulo State University (UNESP) 2.01.P-Tu086

Savannah River National Laboratory 3.02.P-We036

Savannah State University 2.10.P-We119

Save Our Sodus 4.23.P-Tu150

School of Civil Engineering, University of Sydney, Sydney 1.12.P-Tu226

School of Fisheries, Aquaculture, and Aquatic Sciences, College of Agriculture, Auburn University, Auburn, AL, United States 4.15.P-Tu187

School of Fisheries, Aquaculture, and Aquatic Sciences, College of Agriculture, Auburn University, Auburn, AL, United States. 4.15.P-Tu187

School of Life and Environmental Sciences, Deakin University, Melbourne 1.12.P-Tu226

School of Life and Environmental Sciences, Faculty of Science Engineering and Built Environment, Deakin University, VIC, Australia 3.08.P-Th037

School of Mathematics and Statistics, Carleton University, Ottawa, ON 1.09.P-Tu125

School of Pharmaceutical Sciences, The University of Osaka 4.15.P-Tu189

School of Pharmaceutical Sciences, Wakayama Medical University 4.15.P-Tu189

School of Pharmacy, Federal University of Ouro Preto, 35400-000, Ouro Preto, Minas Gerais, Brazil. 4.11.P-We162

School of Resource and Environmental Management, Simon Fraser University, Burnaby, BC, Canada 3.08.P-Th039

School of Science, Edith Cowan University, WA, Australia 3.08.P-Th037

School of the Environment and Chemistry Department, Trent University, Peterborough (ON), Canada 4.19.T-01

School of the Environment, Trent University 4.24.T-04

School of the Environment, University of Toronto 4.16.T-02

School of the Environment, University of Windsor, 401 Sunset Avenue, Windsor, ON N9B 3P4 4.07.T-01

Science & Technology Branch, Environment and Climate Change Canada 4.22.P-Th230

Science Advisory Board for Contaminated Sites 5.16.P-We293

Science and Technology Branch, Environment and Climate Change Canada 3.04.P-We308

Science and Technology Branch, Environment and Climate Change Canada, Burlington, ON, Canada. 4.22.T-04

Science and Technology Branch, Environment and Climate Change Canada, Quebec, QC, Canada 3.07.P-Tu055

Scientific Consultancy – Animal Welfare, Neubiberg 1.13.T-05

SCIEX 4.17.P-Tu238, 4.19.T-03, 4.21.P-Th151, 4.25.T-01

SEBIO - ULHN 2.03.P-Th004

Self 7.12.T-04

Seneca Lake Pure Waters Association 4.23.P-Tu150

Senzagen AB 1.10.T-04

Seoul National University 1.10.P-We302, 4.03.T-05, 5.09.P-Tu292

Seoul National University of Science and Technology 4.17.P-Tu251

Severn Trent Water 1.01.T-04

SGS 4.05.T-04

SGS AXYS 2.13.T-04

SGS AXYS Analytical Services Ltd. 4.01.P-Th160, 4.05.T-04, 4.22.P-Th231

SGS-AXYS 3.07.P-Tu045

Shanghai Key Laboratory of Atmospheric Particle Pollution and Prevention (LAP3), National Observations and Research Station for Wetland Ecosystems of the Yangtze Estuary, Department of Environmental Science and Engineering, Fudan University, Shanghai, 200438, China. 5.09.V-01

Shattuck-St. Mary's School 1.12.P-Tu223

Shell Global Solutions International BV 1.10.T-01

Sherbrooke Pharmacology Institute, University of Sherbrooke, Sherbrooke, QC, Canada 3.07.P-Tu055

Sherbrooke University, Department of Applied Geomatics, Sherbrooke, QC, Canada 4.01.P-Th158

Shimadzu 4.07.P-Tu139, 4.27.T-03, 5.17.P-We260

Shimadzu (China) Co., LTD 4.17.P-Tu231

Shimdazu 5.17.P-We260

Silicone Industry Association of Japan 5.01.P-We062

Simon Fraser University 1.15.T-05, 2.06.T-04, 2.06.T-05, 2.07.P-We050, 2.09.T-04, 2.13.P-Th238, 3.08.P-Th041, 4.04.P-Th107, 4.17.T-03, 4.23.P-Tu153, 7.04.T-01

SiREM 4.05.P-Th129, 6.01.T-04

SiREM Lab 4.05.T-05

SL Ross Environmental Research Ltd 2.06.P-Th115

Smithers 2.07.P-We045, 3.06.P-Tu107, 5.05.P-We015

Smithers LLC 2.07.P-We045, 5.05.P-We013

Social Sciences and Humanities Research Council of Canada 3.07.V-01

Soil Ecotoxicology Labs, Environmental Testing Laboratories – Central Division, Environment and Climate Change Canada, Ottawa, Ontario K1A 0H3, Canada 1.14.T-03

Soutern Illinois University Edwardsville 2.02.P-Th254

South Australian Medical Imaging 4.13.P-Th127

South Carolina Department of Natural Resource 3.08.P-Th052

South Carolina Department of Natural Resources 2.01.P-Tu092, 3.08.P-Th052

South Carolina Sea Grant Consortium 7.11.P-Tu303

Southern California Coast Water Research Project Authority 4.05.P-Th140

Southern California Coastal Water Research 2.05.T-06

Southern California Coastal Water Research Project 4.15.T-05

Southern California Coastal Water Research Project (SCCWRP) 4.05.T-02

Southern Illinois University 2.01.P-Tu076, 2.01.P-Tu092, 2.10.P-We121, 7.10.P-Tu299

Southern Illinois University Carbondale 2.10.P-We121

Southern Illinois University Edwardsville 2.02.P-Th254

Southern Illinois University-Carbondale 4.26.T-05

Southwest Biosphere Reserve Association 4.26.P-Th283

SpecPro Professional Services at US EPA 1.06.P-Th026, 1.06.T-05

SpecPro Professional Services, Duluth, MN 4.02.P-Tu202

Spheros Environmental 2.01.P-Tu072, 5.10.P-We134

Sr data scientist 5.16.P-We292

Stanford University 4.08.P-We030, 8.05.P-We215, 8.09.T-04

Stantec Consulting Ltd., Burnaby, British Columbia, Canada 1.01.P-Tu013

Stantec Inc. 5.09.T-06

State Institution National Antarctic Scientific Center, Ukraine 4.04.T.A-03

State Key Laboratory of Environmental Criteria and Risk Assessment, Chinese Research Academy of Environmental Sciences, Beijing 100012 4.15.P-Tu182

State of Maine - Department of Environmental Protection (DEP) 4.17.P-Tu242

State of Michigan, Department of Environment, Great Lakes, and Energy 2.02.T-06

Statera 4.05.P-Th136, 4.26.P-Th284

Stockholm University 4.04.P-Th086, 4.04.P-Th106, 4.05.P-Th134, 8.08.T-02

Stockton University 2.07.P-We047

Stone Environmental 3.02.T-04

Stone Environmental Inc. 2.03.T-01, 2.03.T-02, 5.15.P-Tu169, 5.18.P-We023

Stoney Creek Environmental Committee (SCEC) 2.08.P-Tu062

STRIDE Center for PFAS Solutions 4.07.T-02, 4.22.P-Th214, 7.02.T-01

Stroud Water Research 2.03.T-01

Structural and Computational Biology, European Molecular Biology Laboratory, Heidelberg, Germany 1.04.P-Th166

Structural Genomics Consortium 4.21.P-Th155

Substitute ApS 8.08.T-02

SUNY ESF 4.26.T-05, 5.02.P-We286

Supervisor and Principle Investigator 8.02.T-01

Sustainable Organic Integrated Livelihoods (SOIL) 8.04.P-Tu018

Swaminarayan University 6.05.T-04

Swedish University of Agricultural Sciences (SLU) 3.07.T.A-06

Swedish University of Agricultural Sciences 1.01.T-06, 1.09.T.B-06, 3.07.V-01

Swedish University of Agricultural Sciences (SLU) 1.01.T-06, 1.09.T.B-06, 3.07.T.A-06, 5.01.T-01

Swiss Federal Institute of Aquatic Science and Technology (Eawag) 1.02.T-06, 1.09.P-Tu124, 2.01.P-Tu088, 4.21.T-03, 4.23.P-Tu148, 7.03.T-06, 7.08.P-Tu135

Swiss Federal Institute of Aquatic Science and Technology (Eawag) / University of Zurich 4.09.T-01

Swiss Federal Laboratories for Materials Science and Technology (EMPA) 3.06.P-Tu108

Syngenta 1.13.T-04, 4.23.T-03, 5.15.P-Tu167, 5.15.P-Tu168

Syngenta Agro GmbH 3.07.P-Tu057

Syngenta Crop Protection 5.10.P-We145, 5.15.P-Tu170

Syngenta Crop Protection AG 1.03.T-02, 2.03.P-Th017, 3.07.P-Tu057, 4.23.T-03, 5.08.P-Tu133, 5.08.P-Tu134

Syngenta Crop Protection LLC 3.07.P-Tu057

Syngenta Ltd 1.03.T-02, 1.09.T.B-05, 1.13.P-Tu036, 2.03.P-Th017, 3.06.T-06, 3.07.P-Tu057, 4.03.T-06, 5.08.P-Tu133, 5.08.P-Tu134, 5.10.P-We145, 5.15.P-Tu169, 5.15.P-Tu170, 5.18.P-We024

Syngenta Ltd. 5.15.P-Tu169

Syngenta Seeds BV 1.09.T.B-05

Syngenta, LLC 5.15.P-Tu171

T

Tactix Government Relations & Public Affairs 7.02.T-05

Takuvik International Research Laboratory, CNRS/Université Laval, 1045 Avenue de la Médecine, G1V 0A6 Québec, Canada 4.04.P-Th103, 4.24.P-We224

Takuvik, Université Laval 4.04.T.B-06

TC Vode 2.01.P-Tu078, 4.23.T-02

Te Ao Mārama Inc 7.07.T-03

Te Ao Marama Inc. 5.07.T-02

Te Ao Mārama Inc. 7.07.T-03

Technological University Dublin 8.02.T-05

TELUQ 2.12.P-We184

TERI-Deakin Nano-biotechnology Centre (TDNBC), Gurugram 8.03.P-We004

Terrafauna 3.07.P-Tu052

TerraHumana Solutions 5.07.P-We165, 5.07.T-03

Tetra Tech 5.09.T-04

Texas A&M University 4.04.P-Th099, 8.08.P-Tu306, 8.08.P-Tu307, 8.08.T-03

Texas Christian University 4.04.P-Th090, 4.04.P-Th098, 4.04.T.B-01

Texas State University 2.12.P-We187, 4.04.P-Th092, 5.09.P-Tu287, 7.02.P-Th208, 7.02.T-04

Texas Tech University 2.08.P-Tu067, 4.06.P-Tu213, 4.22.T-05, 5.15.P-Tu170, 6.03.P-Tu029, 8.03.T-06

The Dow Chemical Company 4.15.P-Tu191

The Harker School 1.12.V-01

The Pew Charitable Trusts 1.12.P-Tu221, 8.08.P-Tu308

The University of Kitakyushu 4.24.P-We232

The University of Rhode Island 5.10.P-We126

The University of Texas at Austin 2.01.P-Tu071

The University of Tokyo 2.07.P-We052

Thermo Fisher Scientific 4.02.P-Tu192

Thomas W Federle LLC 5.14.T-06

Torngat Metals 2.14.P-We197

Toronto Metropolitan University 4.05.P-Th131, 4.24.P-We218, 4.24.T-02, 5.10.P-We129, 5.10.P-We138

Toronto Region Conservation Authority 3.06.T-02

TotalEnergies 1.13.P-Tu039

Towson University 4.06.P-Tu216

Toxicology Centre - University of Saskatchewan 2.02.P-Th252

Toxicology Centre, University of Saskatchewan, Saskatoon, SK, Canada 2.13.T-05

ToxServices LLC 5.10.P-We139, 8.08.T-02, 8.08.T-05

ToxStrategies 4.18.P-Tu276, 5.09.T-01, 5.09.T-02, 5.16.P-We295

Toyama Prefectural University 4.17.P-Tu234

Transport Canada 2.05.P-We043

Trent University 2.01.V-02, 2.12.P-We183, 2.12.P-We185, 4.15.P-Tu172, 5.16.P-We293

Trent University, Peterborough ON 5.14.P-Th197

TrichAnalytics Inc. 2.13.P-Th239, 3.07.P-Tu053, 4.03.T-04, 4.18.P-Tu261, 4.18.P-Tu262

TrichAnalytics Laboratory 1.15.T-03

Tridge Consulting 4.04.T.A-03

Trinity Consultants Canada 2.09.T-03

TRU, University of Toronto 5.07.T-01

Tufts University 8.03.P-We008

Tuktoyaktuk Hunters and Trappers Committee 3.07.P-Tu048

Type One Energy 4.13.P-Th128

TZW: German Water Centre, Karlsruhe 4.09.T-05

U

U.S Geological Survey, Wetland and Aquatic Research Center 3.08.P-Th040

U.S. Army Corps of Engineers 5.02.P-We276, 5.02.P-We277

U.S. Defense Centers for Public Health 1.09.P-Tu118, 1.09.T.A-02

U.S. Environmental Protection Agency 5.08.P-Tu130, 8.05.P-We217

U.S. Environmental Protection Agency (US EPA) 1.02.T-02, 1.03.P-Th018, 1.03.P-Th020, 1.03.T-03, 1.04.P-Th175, 1.05.P-Th181, 1.05.P-Th182, 1.05.T-02, 1.05.T-03, 1.06.P-Th026, 1.08.P-We167, 1.08.P-We170, 1.09.T.A-03, 1.10.T-02, 1.13.T-01, 2.02.P-Th272, 2.10.P-We111, 2.10.P-We112, 3.07.T.B-05, 4.02.P-Tu202, 4.03.T-06, 4.19.P-We207, 5.01.T-02, 5.05.P-We011, 5.06.P-We237, 5.08.P-Tu130, 7.03.T-05

U.S. Environmental Protection Agency (US EPA) 1.04.P-Th175, 1.10.T-02

U.S. Fish and Wildlife Service 1.04.P-Th175, 1.15.T-03, 2.02.P-Th274, 2.05.T-03, 3.07.T.A-01, 3.08.T-06

U.S. Fish and Wildlife Service, Division of Migratory Bird Management 3.08.P-Th038

U.S. Geological Survey 1.15.T-06, 2.05.T-03, 3.08.T-06

U.S. Geological Survey (USGS) 1.06.T-01, 1.08.P-We166, 1.08.P-We167, 1.15.P-We205, 1.15.T-03, 2.01.T.A-05, 2.02.P-Th279, 2.04.T-05, 2.05.T-03, 2.12.P-We182, 2.13.P-Th242, 2.13.P-Th243, 3.01.P-Th031, 3.01.T-01, 3.02.T-03, 3.02.T-06, 3.04.P-We305, 4.04.T.A-06, 4.17.P-Tu241, 4.17.P-Tu247, 4.17.T-04, 4.23.P-Tu149, 4.23.T-05, 5.09.P-Tu296, 6.01.T-03

U.S. Geological Survey (USGS) 2.14.T-03

U.S. Geological Survey Central Midwest Water Science Center 3.06.P-Tu105

U.S. Geological Survey Columbia Environmental Research Center 3.06.P-Tu105

U.S. Geological Survey Columbia Environmental Research Center; University of Missouri 3.06.P-Tu105

U.S. Geological Survey Oklahoma-Texas Water Science Center 3.06.P-Tu105

U.S. Geological Survey Western Fisheries Research Center 1.06.T-04

U.S. Geological Survey, Columbia Environmental Research Center 2.02.P-Th274

U.S. Geological Survey, Eastern Ecological Science Center 3.08.P-Th038

U.S. Geological Survey, Missouri Cooperative Fish and Wildlife Research Unit, University of Missouri 2.02.P-Th274

U.S. Geological Survey, Western Fisheries Research Center, 6505 NE 65th Street, Seattle, WA 98115, USA 1.08.P-We166, 4.09.P-We076

UC Davis 1.07.P-We086, 3.08.P-Th051

UC Santa Barbara 1.12.P-Tu222

UdeA - Medellín 2.10.P-We113

UdeM 2.14.P-We191

UFSCAR - Campus Sorocaba 2.10.P-We113

UiT The Arctic University of Norway 3.08.T-03

UK Centre for Ecology and Hydrology, Wallingford 3.07.T.A-06

UK Centre for Ecology and Hydrology, Wallingford, Oxfordshire 3.07.T.A-06

UKCEH 2.01.T.B-03

UL Research Institutes 4.01.T-02, 4.10.P-Tu007

ULRI Chemical Insights 4.03.T-02

UMCES, Chesapeake Biological Laboratory 7.12.T-03

Umeå University 4.04.P-Th087, 4.04.T.A-02, 4.16.T-01, 5.01.T-01

uMngeni-uThukela Water 4.11.P-We164

UMR-I 02 Environmental Stress and Aquatic Biomonitoring (SEBIO), University of Le Havre Normandy 1.13.P-Tu037

Undergraduate Student 4.15.T-06

UNESP 2.10.P-We113

UNESP - ICTS 2.10.P-We113

UNESP ICTS 2.10.P-We113

Unilever 1.05.P-Th180, 1.05.T-05, 1.09.T.B-02, 5.09.T-02

United Energy Group 5.09.P-Tu286

United Kingdom Centre for Ecology & Hydrology (UKCEH) 1.01.T-04, 1.01.T-05, 2.02.P-Th276, 2.02.P-Th277

United States Geological Survey 4.22.T-06

United States Geological Survey (USGS), Eastern Ecological Science Center 6.01.T-02

United States Geological Survey (USGS), Upper Midwest Environmental Sciences Center 6.01.T-02

Univeristy of Maryland Eastern Shore 6.05.P-Th204

Universidad Abierta y a Distancia de México 3.06.P-Tu115

Universidad Autónoma Metropolitana-Iztapalapa 2.02.P-Th280, 3.06.P-Tu115, 4.15.P-Tu180

Universidad Castilla La Mancha 3.01.P-Th029

Universidad de Los Andes 7.07.T-02

Universidad Nacional Autónoma de México (UNAM) 5.09.P-Tu298

Universidad Nacional de San Agustín de Arequipa 2.10.P-We113

Universidad Nacional del Noroeste de la Provincia de Buenos Aires 4.11.P-We161

Universidade Estadual Paulista Júlio de Mesquita Filho - Instituto de Ciência e Tecnologia de Sorocaba (ICTS - UNESP) 2.01.P-Tu086

Universidade Federal de São Carlos (UFSCAR), Campus Sorocaba 2.01.P-Tu086

Universidade Federal do Sul da Bahia 2.10.P-We104, 3.07.T.A-05

Université d'Ottawa 2.10.P-We116

Universite de Montreal 3.08.P-Th041, 7.10.P-Tu301

Université de Montréal 2.01.P-Tu079, 4.02.P-Tu205, 5.02.T.B-05, 5.16.T-06

Université de Montréal (UdeM) 4.26.T-05

Université de Pau et des Pays de l'Adour, CNRS, IPREM, Pau, France 2.14.T-02

Université de Saint-Boniface 4.04.P-Th105

Université de Sherbrooke 4.01.T-03, 4.13.T-02

Université de technologie de Compiègne, ESCOM, Alliance Sorbonne Université, TIMR 4.17.P-Tu231

Université du Québec à Chicoutimi 1.02.P-We241

Université du Québec à Montréal 2.14.P-We194, 2.14.T-04, 4.23.P-Tu155

Université du Québec à Montréal (UQAM) 2.14.P-We193

Université du Québec à Rimouski (UQAR) 2.10.P-We115, 4.04.T.A-01

Université du Québec en Abitibi-Témiscamingue 2.01.T.B-02

Université du Québec en Abitibi-Témiscamingue (UQAT) 2.09.T-06

Université Franche-Comté 3.06.T-05

Université Laval 1.02.P-We241, 2.01.T.B-02, 2.03.P-Th007, 4.01.T-03, 4.04.T.B-06, 4.23.P-Tu152, 8.01.T-04, 8.09.P-Tu312

Université Le Havre Normandie, Université de Reims Champagne-Ardenne, INERIS, Normandie Univ, UMR-I 02 SEBIO, F-76600 Le Havre, France. 2.01.P-Tu068

Université Sainte-Anne 2.07.P-We044

Université TÉLUQ 4.23.P-Tu155

University College Dublin 3.06.T-04

University Hospital Cologne 1.06.P-Th027

University of British Columbia 2.08.P-Tu063

University of Maryland Eastern Shore 6.05.P-Th204

University of Alaska Anchorage, Department of Computer Science and Engineering, Anchorage, AK 4.04.T.A-06

University of Alaska Fairbanks 2.10.P-We107, 4.04.P-Th105

University of Alberta 1.15.P-We206, 2.01.T-05, 2.04.P-Tu102, 2.04.T-04, 2.04.T-06, 2.06.T-01, 2.06.T-04, 2.10.P-We115, 3.07.V-01, 4.02.P-Tu206, 4.04.P-Th088, 4.04.P-Th089, 4.04.P-Th093, 4.04.T.B-02, 4.04.T.B-03, 4.10.P-Tu002, 4.10.P-Tu005, 4.10.P-Tu006, 4.18.P-Tu274, 4.19.P-We211, 4.23.P-Tu148, 4.24.P-We220, 4.25.P-Th191, 4.25.T-02, 4.27.P-We301, 4.27.T-06

University of Alberta, Natural Resources Canada-CanmetENERGY Devon 4.18.P-Tu274

University of Auckland 5.06.T-02, 5.07.T-02, 7.07.T-03

University of Aveiro (UA) 1.04.P-Th167, 1.13.P-Tu038

University of Benin, Benin-City, Edo State, Nigeria. 4.23.V-01

University of Benin, Benin-City, Nigeria. 2.02.V-01

University of Benin, Nigeria 1.08.P-We174

University of Benin, Nigeria and Taylor University, Upland, USA 1.08.P-We174

University of Bergen 1.03.T-04, 3.07.V-01

University of Birmingham 5.02.T.A-05

University of Bologna 4.04.P-Th105

University of Bristol 4.25.T-04

University of British Colombia, Ocean Wise Conservation Association 4.26.T-04

University of British Columbia 2.07.P-We048, 2.08.P-Tu062, 2.08.P-Tu063, 4.17.T-03, 4.17.T-05, 5.06.T-04, 8.09.T-05

University of British Columbia (UBC) 2.07.P-We048, 2.08.P-Tu062, 4.17.T-05, 5.07.T-01, 5.16.T-02, 7.05.P-We158, 8.09.T-05

University of Caen Normandy 1.13.P-Tu037

University of Caen Normandy, University of Rennes, CNRS UMR 6552 CEEC (Centre for Studies in Ethology and Cognition) 1.13.P-Tu037

University of Calgary 2.06.P-Th116, 2.06.P-Th119, 2.10.P-We107, 2.12.P-We187, 2.14.P-We192, 3.07.T.B-03, 4.04.P-Th091, 4.04.P-Th092, 4.04.P-Th105, 4.04.P-Th107, 4.04.T.A-04, 4.04.T.A-05, 4.04.T.A-06

University of California Davis 2.03.P-Th001, 3.08.P-Th049, 4.19.T-06, 4.21.P-Th147, 7.05.P-We156

University of California Davis (UC Davis) 1.07.P-We090, 2.01.T.B-04, 2.02.P-Th278, 2.02.T-03, 3.08.P-Th051, 4.10.T-05, 4.18.P-Tu267, 4.18.P-Tu272, 4.19.T-06, 4.21.P-Th147, 4.21.T-03, 4.21.T-06, 4.22.P-Th224, 4.23.T-04, 6.02.P-Th112, 7.05.P-We156, 7.10.P-Tu299

University of California Irvine (UC Irvine) 4.10.T-02

University of California Los Angeles (UCLA) 4.19.T-06

University of California Riverside 2.01.P-Tu071

University of California San Diego (UC San Diego) 4.05.P-Th136, 4.26.P-Th284

University of California Santa Barbara 5.08.P-Tu131

University of California Santa Barbara (UC Santa Barbara) 1.06.P-Th027, 1.06.T-02, 1.06.T-03, 4.22.P-Th232

University of California Santa Barbara (UC Santa Barbara) 1.12.P-Tu222

University of California, Berkeley 4.22.T-01, 5.02.P-We270

University of California, Davis 2.02.P-Th278, 4.23.P-Tu151

University of California, Irvine 8.05.P-We216, 8.08.T-03

University of California, Riverside, Environmental Sciences Department. Riverside, CA. 4.17.P-Tu233

University of California, Santa Barbara 1.06.T-02

University of California: Davis 4.08.P-We030

University of Cartagena 1.07.P-We092, 5.10.P-We141

University of Coimbra 5.15.P-Tu166

University of Cologne 1.06.T-02, 1.06.T-03

University of Colorado Anschutz Campus 1.04.P-Th168

University of Colorado Boulder 4.10.T-04, 4.22.P-Th237, 5.14.T-05

University of Colorado Boulder (May 2026 graduate) 4.22.P-Th237

University of Colorado, Boulder 4.22.T-01

University of Connecticut 1.15.T-03, 4.02.P-Tu197, 4.08.P-We030

University of Connecticut Department of Chemistry 6.05.T-03

University of Connecticut Department of Molecular and Cell Biology 6.05.T-03

University of Copenhagen 5.16.T-04

University of Delaware 5.01.T-06

University of Eastern Finland 2.02.P-Th249

University of Exeter 2.05.P-We039, 2.07.T-05, 4.05.T-01, 4.22.P-Th225, 5.08.P-Tu129

University of Florida 1.04.P-Th168, 1.04.P-Th174, 1.05.P-Th179, 2.01.P-Tu092, 2.02.P-Th251, 2.05.P-We041, 2.05.P-We042, 2.05.T-01, 2.07.T-03, 2.07.T-04, 3.02.P-We038, 3.02.T-02, 4.02.T-03, 4.04.P-Th105, 4.06.P-Tu217, 4.06.T-04, 4.23.P-Tu161, 5.02.P-We275, 5.02.P-We282, 5.02.T.A-06, 5.11.P-Tu163, 5.14.T-04

University of Florida, Department of Environmental and Global Health 3.08.P-Th040

University of Florida, Department of Microbiology and Cell Science 3.08.P-Th040

University of Florida, Department of Wildlife Ecology and Conservation 3.08.P-Th040

University of Georgia 1.04.P-Th168

University of Georgia - Savannah River Ecology Laboratory 4.05.P-Th138

University of Georgia's Savannah River Ecology Laboratory 3.02.P-We036

University of Guelph 1.12.P-Tu224, 2.01.P-Tu069, 2.02.P-Th263, 2.02.T-04, 2.03.P-Th010, 2.05.P-We040, 2.06.P-Th113, 2.10.P-We102, 3.02.P-We034, 3.07.T.B-03, 4.04.P-Th091, 4.04.T.A-04, 4.19.T-05, 4.22.T-06, 5.02.P-We279, 5.02.T.B-03, 5.07.T-01

University of Guelph, School of Environmental Sciences 3.06.T-01

University of Guelph, School of Environmental Sciences, Guelph, ON 2.07.P-We058

University of Helsinki 8.01.T-03

University of Illinois at Urbana-Champaign 1.08.P-We169

University of Iowa 4.05.P-Th132, 4.05.P-Th133, 4.21.T-05, 4.22.T-03, 5.02.P-We285, 7.11.P-Tu305

University of Johannesburg 8.03.T-04

University of KwaZulu-Natal 5.10.P-We132

University of KwaZulu-Natal (UKZN) 4.18.V-02

University of Laval 4.15.T-01, 8.09.T-03

University of Lethbridge 1.03.T-04, 2.06.P-Th113, 2.06.P-Th119, 4.23.P-Tu147, 5.06.T-04

University of Liège 3.03.P-Tu041

University of Louisiana, Lafayette 4.07.P-Tu144

University of Maine 3.02.P-We032, 5.09.P-Tu294

University of Maine Cooperative Extension 5.09.P-Tu294

University of Manitoba 1.03.T-04, 2.01.P-Tu091, 2.06.T-02, 2.06.T-05, 2.08.P-Tu059, 2.08.P-Tu060, 2.08.P-

Tu061, 2.09.P-Tu033, 4.04.P-Th095, 4.04.P-Th105, 4.04.T.A-04, 4.04.T.B-03, 4.09.P-We070, 4.25.P-Th191, 5.02.T.B-03, 6.01.P-We082, 6.03.P-Tu024

University of Mary Washington 2.01.T.B-06, 2.02.P-Th250, 2.10.P-We101, 2.10.P-We114, 7.02.P-Th207

University of Maryland 2.01.T.B-06, 7.02.P-Th206

University of Maryland Center for Environmental Science 2.01.T.B-06, 2.03.P-Th002, 2.03.T-06, 5.14.T-06

University of Maryland Center for Environmental Science, Solomons, MD 3.02.T-06

University of Maryland College Park 3.01.P-Th031

University of Maryland Eastern Shore 2.07.T-04, 3.03.P-Tu044, 4.22.P-Th236, 4.23.P-Tu156, 5.02.P-We287, 6.05.P-Th204

University of Massachusetts Lowell (UMass Lowell) 8.08.T-02, 8.08.T-06

University of Miami 2.01.T.B-04

University of Michigan 4.24.T-05, 5.02.T.B-03

University of Minnesota 2.13.T-01, 4.09.T-04, 4.22.P-Th227, 5.04.T-03, 5.04.T-05

University of Minnesota Duluth 1.06.P-Th026, 2.13.P-Th244, 4.17.T-02

University of Missouri 1.06.T-01, 6.01.T-03

University of Montreal 2.14.T-01, 2.14.T-06, 3.07.V-01, 4.02.P-Tu195, 4.04.P-Th102, 4.15.P-Tu184, 5.02.P-We278

University of Montreal (UdeM) 1.01.T-03, 1.07.P-We085, 2.01.T.B-02, 2.03.P-Th007, 2.14.P-We188, 2.14.P-We192, 2.14.P-We193, 2.14.T-01, 3.06.T-04, 3.08.T-01, 4.04.P-Th102, 4.15.P-Tu183, 4.15.T-04, 4.18.P-Tu264, 4.22.T-04, 4.26.T-05, 5.02.P-We278, 5.16.T-06

University of Montreal (UdeM) 6.03.P-Tu025

University of Nantes 2.07.T-02

University of Nevada Reno 5.01.P-We063

University of New Brunswick 2.13.P-Th241

University of New Hampshire 2.06.T-02

University of New Mexico 4.10.P-Tu003

University of North Carolina 8.09.T-04

University of North Dakota 5.10.P-We126

University of North Georgia 4.05.P-Th136, 4.26.P-Th284

University of Northern British Columbia 2.06.T-05

University of Notre Dame 4.02.T-03, 4.06.T-04

University of Osnabrueck 5.08.P-Tu129, 5.15.P-Tu166

University of Ottawa 2.03.P-Th007, 2.06.T-05, 4.15.P-Tu176, 4.24.T-02, 6.01.P-We082, 7.04.T-01

University of Ottawa; Kilgour & Associates Ltd. 4.13.P-Th123

University of Peredeniya 4.08.P-We030

University of Pittsburg at Bradford 5.03.P-We212

University of Pittsburgh 5.01.T-05, 7.05.P-We158

University of Pittsburgh at Bradford 5.03.P-We212, 5.03.P-We213, 5.03.P-We214

University of Port Harcourt (UniPort) 4.18.V-01

University of Quebec 8.09.P-Tu312, 8.09.T-01, 8.09.T-03

University of Québec 8.09.T-03

University of Quebec at Rimouski 3.07.V-01

University of Quebec at Rimouski (UQAR) 2.03.P-Th003, 2.03.P-Th004, 2.05.T-05, 2.14.T-06, 3.01.P-Th030, 3.07.T.B-03, 3.08.P-Th042, 4.24.P-We228

University of Quebec in Abitibi-Temiscamingue 4.14.P-We179

University of Quebec in Montreal 2.14.P-We188

University of Quebec in Montreal (UQAM) 1.01.T-03, 1.07.P-We085, 2.14.P-We188, 2.14.P-We192, 2.14.P-We193, 2.14.T-01, 2.14.T-06, 3.01.P-Th032, 3.03.P-Tu041, 3.07.P-Tu048, 3.07.T.B-02, 3.07.T.B-04, 3.08.T-01, 4.04.T.A-01, 4.05.P-Th149, 4.13.P-Th124, 4.14.P-We176, 4.18.P-Tu280

University of Quebec in Montreal (UQAM) 2.01.P-Tu093

University of Quebec in Rimouski (UQAR) 2.14.T-06

University of Queensland 3.03.P-Tu042

University of Rhode Island 3.02.P-We032, 4.05.T-06, 4.18.P-Tu275, 4.25.P-Th194

University of Rhode Island - Graduate School of Oceanography 4.09.P-We069

University of Saskatchewan 1.01.T-03, 1.01.T-05, 1.02.P-We240, 1.04.P-Th171, 1.10.P-We303, 1.15.T-04, 2.01.T.B-01, 2.02.P-Th258, 2.02.P-Th276, 2.02.P-Th277, 2.02.T-06, 2.06.P-Th113, 2.06.P-Th119, 2.10.P-We110, 2.13.T-05, 3.01.T-03, 3.07.T.A-03, 3.08.P-Th035, 3.08.P-Th053, 4.04.P-Th105, 4.04.T.A-05, 4.17.P-Tu250, 4.23.T-01, 5.01.T-03, 5.04.P-We253, 5.09.T-02, 6.03.P-Tu030

University of Seoul 2.01.P-Tu084, 5.06.P-We238

University of Sheffield 5.15.P-Tu166

University of Sherbrooke 3.01.P-Th032, 3.07.T.B-02, 8.01.T-04

University of South Carolina 3.07.P-Tu050, 4.17.P-Tu236, 7.03.T-05

University of South Carolina - Baruch Marine Field Laboratory 7.11.P-Tu303

University of South Carolina Aiken (USCA) 2.10.P-We103

University of South Carolina, Baruch Marine Field Laboratory 2.13.P-Th246

University of South Dakota 4.04.P-Th098, 4.23.P-Tu149

University of Southampton 1.03.T-04

University of Strathclyde 2.08.P-Tu060, 6.01.P-We082

University of Sydney 7.08.P-Tu137

University of Tennessee Knoxville 1.06.P-Th024, 1.06.T-03, 3.06.P-Tu111, 3.07.P-Tu056, 4.13.P-Th127, 4.13.T-05

University of Tennessee, Knoxville 4.13.P-Th128

University of Texas Austin 2.07.P-We057, 4.04.P-Th092, 4.04.T.A-06, 4.22.P-Th217, 5.17.P-We258

University of Tirana 2.13.T-06

University of Tokyo 5.04.P-We247

University of Toronto 1.13.P-Tu040, 2.03.P-Th010, 2.13.T-03, 3.02.T-05, 3.03.P-Tu041, 3.08.P-Th050, 4.01.P-Th156, 4.01.P-Th158, 4.01.P-Th335, 4.01.T-04, 4.01.T-05, 4.01.T-06, 4.04.P-Th107, 4.04.T.A-05, 4.05.P-Th134, 4.05.P-Th149, 4.07.P-Tu141, 4.07.P-Tu142, 4.07.T-03, 4.07.T-05, 4.08.P-We031, 4.09.P-We067, 4.09.T-06, 4.15.P-Tu176, 4.16.P-Tu100, 4.19.P-We210, 4.19.T-04, 4.21.P-Th155, 4.22.T-02, 4.24.T-01, 4.24.T-03, 4.25.T-03, 4.25.T-05, 4.26.T-02, 5.01.P-We061, 5.01.P-We063, 5.10.P-We129, 5.10.P-We138, 7.07.T-02, 7.10.P-Tu301, 8.03.P-We005

University of Toronto Scarborough 1.02.P-We241, 4.06.P-Tu219, 4.24.P-We225

University of Toronto; Chinese Academy of Agricultural Sciences (CAAS) 4.07.P-Tu142

University of Toronto; Nankai University 1.13.P-Tu040

University of Ulsan 6.03.P-Tu020

University of Victoria 2.09.P-Tu032, 2.09.T-01, 2.09.T-03, 2.09.T-04, 4.17.T-05, 5.02.P-We288

University of Vienna 4.24.P-We226

University of Washington 2.10.P-We125, 2.13.P-Th245

University of Washington Tacoma 2.13.T-02, 4.09.P-We076

University of Washington, Olympic Natural Resources Center 5.10.P-We152

University of Waterloo 1.02.P-We246, 2.01.P-Tu085, 2.02.P-Th261, 2.06.P-Th116, 2.10.P-We099, 3.02.T-05, 4.16.T-04, 4.21.P-Th148, 4.22.P-Th215, 4.22.P-Th216, 4.23.P-Tu148, 4.27.T-06, 5.17.P-We262, 5.17.P-We263, 6.01.T-04

University of Western Ontario 2.01.V-02, 4.16.T-03

University of Windsor 4.04.T.B-05, 4.15.P-Tu181

University of Wisconsin Madison 2.03.T-03, 5.07.T-04

University of Wisconsin-Madison 5.09.P-Tu294

University of Zurich 2.01.P-Tu088

University of Zürich 4.09.T-01

Universtity of British Columbia 4.17.T-05

Univesity of South Carolina 3.07.P-Tu050

UQAM 2.12.P-We184, 2.14.P-We191, 2.14.P-We196, 4.23.P-Tu152

UQAM, LAE 4.23.P-Tu152

UQAR 2.03.P-Th004, 2.05.T-05

UQTR 2.09.T-02

US Army Engineer Research and Development Center (ERDC) 5.02.P-We276, 5.02.P-We277

US Department of Agriculture-ARS 2.13.P-Th242

US Environmental Protection Agency 1.13.P-Tu034, 3.07.T.B-05, 5.09.P-Tu295

US EPA 1.06.T-05, 7.12.T-01

US Geological Survey 3.01.P-Th031

USDA APHIS 3.08.T-04

USDA-ARS 2.03.T-05

USDA-ARS, Pasture Systems and Watershed Management Research Unit, University Park, Pennsylvania 4.06.P-Tu215

USDA-ARS, Soil and Water Research Unit, Pendleton, Oregon 4.06.P-Tu215

USEPA/ORD/CPHEA/PESD/FEB, U.S. EPA, Corvallis, OR 4.23.P-Tu149

USGS 1.15.P-We200, 2.14.T-03, 3.02.T-01, 4.08.P-We029, 4.17.P-Tu249

USGS California Water Science Center 4.23.P-Tu150

USPS 7.10.P-Tu300

V

Valladolid University 4.04.P-Th091

Veterinary Biosciences, College of Veterinary Medicine, The Ohio State University, Columbus, OH 1.08.P-We172

Virginia Institute of Marine Science 4.15.P-Tu174, 4.15.P-Tu175, 4.15.P-Tu176, 4.15.P-Tu178, 4.27.T-02

Virginia Institute of Marine Science (VIMS), William & Mary. Gloucester Point, VA. 4.17.P-Tu233

Virginia Institute of Marine Science, William & Mary 4.15.T-03

Virginia Institute of Marine Science, William and Mary 4.15.T-03

Virginia Polytechnic Institute and State University 4.01.T-06

Vizgen Inc, 150 Bear Hill Rd, Waltham, MA, 02451, USA 1.04.P-Th166

VU University Amsterdam (VU) 1.07.P-We088

W

Wageningen University & Research 2.01.T.A-03

wageningen university and research 2.01.T.A-04

Wageningen University and Research (WUR) 2.01.T.A-04, 3.06.T-06, 5.15.P-Tu166

Wageningen University and Research (WUR) 2.01.T.A-03

Washington Department of Fish & Wildlife, Olympia, WA 98501, USA 1.08.P-We166

Washington State Department of Ecology 4.17.P-Tu249

Washington State Department of Health 8.08.T-02

Washington State University 2.13.T-02, 3.08.T-04, 4.26.T-01, 5.16.T-03

Washington State University (WSU) 2.13.P-Th245, 2.13.T-02

Watchfrog S.A 1.13.T-03

Watchfrog S.A. 1.07.P-We088, 1.13.T-03

Water and Air Quality Bureau, Healthy Environments and Consumer Safety Branch (HECSB), Health Canada, Ottawa, ON, Canada 5.10.P-We128

Water Environment and Urban Systems Laboratory (LEESU) 2.09.T-06

Water Science and Technology Directorate, Environment and Climate Change Canada, Burlington, ON L7S 1A1 4.07.T-01

Water Science and Technology Directorate, Environment and Climate Change Canada, Burlington, ON, Canada 2.06.P-Th114

Waterborne Environmental Inc. 4.03.T-06

Waters Corporation 4.01.P-Th163, 4.02.P-Tu201, 4.07.P-Tu145, 4.19.P-We208, 4.21.P-Th154

Wayne State University 2.02.P-Th251, 4.24.P-We218, 5.02.T.A-06

wca environment Ltd 2.03.P-Th012

wca environment Ltd. 1.01.P-Tu010, 1.01.T-04, 1.01.T-05, 1.10.T-01, 1.13.P-Tu036, 1.13.P-Tu039, 2.02.P-Th256, 2.02.P-Th276, 2.02.P-Th277, 2.06.P-Th121, 5.14.T-03, 7.03.T-02

Weenusk First Nation 2.12.P-We183

Wesleyan University 2.10.P-We098

Western University 2.12.P-We183

Western Washington University 2.10.P-We125, 5.16.P-We293, 6.02.P-Th110

Wilder Institute 3.07.T.B-01

Wildlife and Landscape Science Directorate, Environment and Climate Change Canada, Ottawa, ON, Canada 2.06.P-Th114, 2.06.T-03

Wildlife Conservation Society (WCS) Canada 2.12.P-We183

Wilfrid Laurier University 2.01.P-Tu091, 2.02.P-Th261, 2.04.P-Tu102, 2.04.T-01, 2.04.T-04, 2.04.T-06, 2.14.P-We190, 4.04.P-Th088

Wilfrid Laurier University, Environment and Climate Change Canada 2.14.P-We190

William & Mary's Batten School of Coastal & Marine Sciences | The Virginia Institute of Marine Science 4.24.T-03

William & Mary's Batten School of Coastal & Marine Sciences and the Virginia Institute of Marine Science 4.24.T-03

Wings Over Water Research Institute (WOWRI) and Calvin University 7.04.T-06

Wings Over Water Research Institute (WOWRI) and University of Maryland 7.04.T-06

Wood Buffalo National Park, Parks Canada 3.07.T.B-01

Woodard & Curran Inc. 1.14.T-05

Woods Hole Oceanographic Institution 1.06.T-06

World Bank Africa Centre of Excellence in Oilfield Chemicals Research (ACE-CEFOR), University of Port Harcourt, PMB 5323 Choba Port Harcourt, Rivers State 6.05.V-02, 6.05.V-03

WSP 1.15.P-We203

WSP Canada Inc. 2.02.P-Th265

WSP USA Inc. 4.02.P-Tu208

WSP USA, Inc. 4.02.P-Tu208

Y

Yale School of Public Health 5.17.P-We261

Yale School of the Environment 4.06.T-03

Yale University 2.07.T-03, 4.02.P-Tu197

Yong In university 2.02.P-Th275

Yong In University 1.06.P-Th021, 1.07.P-We089, 2.02.P-Th264, 2.02.P-Th275

Yongin University 1.02.P-We244, 1.06.P-Th025, 5.06.P-We239

York University 1.04.P-Th169, 1.14.T-01, 2.02.P-Th262, 2.02.T-01, 2.02.T-02, 4.01.T-04, 4.10.P-Tu001, 4.10.P-Tu006, 4.10.T-01, 4.25.P-Th192, 4.25.T-03, 4.25.T-05, 4.25.T-06

Yukon-Charley Rivers National Preserve 4.04.P-Th105

Yunnan University 4.05.P-Th136, 4.26.P-Th284

Z

Zhejiang Engineering Research Center of Micro/Nano-Photonic/Electronic System Integration, Hangzhou, Zhejiang 310030, China; Department of Electronic and Information Engineering, School of Engineering, Westlake University, Hangzhou, Zhejiang 310030, China. 5.09.V-01

Zhejiang Key Laboratory of Precise Synthesis of Functional Molecules, Instrumentation and Service Center for Molecular Sciences, Westlake University, Hangzhou, Zhejiang 310030, P. R. China. 5.09.V-01

Zhejiang Provincial Center for Disease Control and Prevention 5.01.P-We065

Zubrod Environmental Data Science 1.03.T-02

Society of Environmental Toxicology and Chemistry
Environmental Quality Through Science®

www.setac.org

